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STOPPING WATER POLLUTION AT ITS SOURCE

MISA

Municipal/Industrial Strategy for Abatement

BEST AVAILABLE

POLLUTION CONTROL TECHNOLOGY

PITS AND QUARRIES

Ontario

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PITS AND QUARRIES

Report prepared by:

Kilborn Inc.
and
Environmental Applications Group Ltd.

PROPRIETARY AND REGISTERED TRADE NAMES ARE USED IN THIS REPORT WHERE APPROPRIATE TO IMPROVE THE CLARITY OF EXPLANATIONS OR TO DEFINE SOURCES OF INFORMATION. THIS SHOULD NOT BE CONSTRUED AS APPROVAL OR RECOMMENDATION FOR USE IN ONTARIO ON THE PART OF THE MINISTRY OF ENVIRONMENT AND ENERGY. THE MINISTRY RECOGNIZES THAT THE REGISTERED TRADE NAMES REMAIN THE PROPERTY OF THEIR REGISTERED OWNERS.

wp/3761-15/AGG

ONTARIO MINISTRY OF THE ENVIRONMENT

INDUSTRIAL MINERALS SECTOR

AGGREGATES DIVISION

BEST AVAILABLE POLLUTION CONTROL TECHNOLOGY

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ONTARIO MINISTRY OF THE ENVIRONMENT
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BEST AVAILABLE POLLUTION CONTROL TECHNOLOGY

EXECUTIVE SUMMARY

Kilborn Inc. (Kilborn) and The Environmental Applications Group Limited (EAG) were retained by the Ontario Ministry of the Environment (OMOE) to undertake a study to identify Best Available pollution control Technologies (BAT) applicable to effluents monitored under the Municipal/Industrial Strategy for Abatement (MISA) program for the Industrial Minerals Sector, Aggregate Division. BAT has been defined by OMOE as a combination of demonstrated treatment technologies and in-plant controls. The Aggregates Division comprises Quarries, Shale and Common Clay, and Sand and Gravel producers.

Specific objectives of the study are:

1) to provide information on existing, or alternate industrial processes, effluent treatment works and processes, chemical substitutions, and employment of water reduction or reuse;
2) to provide relevant information on design specifications, as-found treatment performance, operating conditions, effluent quality remediation and capital and operating costs of the technologies; and
3) to recommend, where possible, five options for BAT for each operation or group of operations within the Division.

Study efforts were focused on those areas of the world mining community where modern waste water treatment practices are known to be employed, and where mining and producing operations for aggregates are similar to those used in Ontario. Where treatment technologies were determined to be climate dependant, relevance to the Ontario setting was established. Canada, the United States, western/northwestern Europe, and Australia/New Zealand were considered to be the relevant geographic areas of investigation.

Data for the study were obtained from: the MISA effluent monitoring data base, study team files, published documents, and from contacts with a large number of mining and processing operations. Contacts in this latter instance were made through use of a questionnaire and telephone follow-up. In many cases, questionnaires were completed from verbal responses. Confidentiality was an issue with

some operators. Site visits were made to operations in Europe to review technologies different from those commonly employed in North America and to selected Ontario operations.

Visits to US plants were not made mainly because many of the aggregates producers operate without surface water discharge, due to their location in net evaporation climatic zones. US plants located in such zones generally practise `zerovolume discharge'. Where effluent discharge is practised in the United States, treatment systems are generally comparable to those used in Canada.

The MISA effluent monitoring data base, for the period August 1, 1990 to July 31, 1991 formed the basis for effluent quality comparison for all monitored Ontario plants. The data base available for this study was the unedited version for which quality assurance/quality control correction has not yet been applied. From this unedited version, a list of 13 Priority 1 parameters was prepared by OMOE and these parameters were those selected for application of treatment technologies.

A large proportion of the Priority 1 parameters are judged to be at sufficiently low concentration to render them not treatable by available technology. The main parameter of concern and which is judged to be treatable is Total Suspended Solids. Oil and Grease is generally present at concentrations below treatable levels.

Preliminary results of toxicity testing were available but analysis of data was not completed by OMOE prior to completion of this study. All Aggregate Division effluents which were monitored are considered to be non-toxic to either Rainbow Trout or Daphia magna.

In addition to a review of operating plants and waste water control technologies, a comprehensive review of generic waste water control technologies which are and could potentially be applied to the Aggregates Division was completed.

To facilitate evaluation of interprovincial and international waste water treatment control technologies, a comparison of applicable world-wide regulations, guidelines and control practices was made. Standards are generally comparable among the areas reviewed with some notable exceptions. Standards for suspended solids are among the more variable ones encountered.

With minor exceptions, ammonia does not appear to be regulated outside Canada or outside the provinces of Ontario, British Columbia and Saskatchewan. Monitoring for toxicity was found to be similarly limited outside of Ontario and British Columbia.

Based on plant operations and performances relative to environmental standards, an inventory of world-wide operations was prepared. Only a limited amount of data could be obtained from operations outside Ontario for various reasons and in some cases the monitoring protocol is notably different from that applied in Ontario rendering quality values less meaningful.

A review of treatment technologies currently in use within the aggregates producing and related industries, was carried out to identify those technology trains which meet, or could meet, minimum acceptable Ontario US EPA and World wide BAT requirements. Consideration of maximum pollution prevention and progress towards zero discharge were also considered in this review.

Based on the review, the operations or plants demonstrating the application of BAT are selected for the sub-sectors of quarries and clay and shale. Selection of the BAT plant is made on the basis of best overall effluent quality in combination with the application of treatment technology. In the quarries sub-sector a group of operations was judged to represent BAT. For the remaining sub-sector of sand and gravel only one discharger was monitored. In this case, preferred technologies are advocated for treatment of effluents where applicable.

Almost without exception the analysis of regulations, water quality monitoring and treatment technology, illustrates that control of suspended solids is the primary concern. For control of suspended solids, various configuration of sumps, settling ponds and decant ponds are the technologies demonstrated by the selected BAT operations. Ammonia and phenolics are not subject to specific treatment methods.

Within each category or sub-sector, the application of the selected technology in order to attain the effluent quality demonstrated by the BAT plant is assessed. For all such operations, estimates of the required capital and operating costs are shown. In addition to reaching levels demonstrated by Ontario, US and World BAT plants, costs are estimated for attainment of Maximum Pollution Prevention and Zero (Volume) Discharge.

It must be emphasized that these estimated costs are considered typical for each sub-sector but do not include site specific costs associated with unique conditions, topography, site availability and background water quality. Further work includes detailed site investigations and effluent treatment testing would be required to improve the applicability of the cost estimates to specific operations.

Pollution Prevention Practices (PPP) including Best Management Practices (BMP) are employed throughout the industry in an effort to optimize performance, and to minimize environmental impacts. Improving on the efficiency of waste water use and recycle, segregation of cooling and storm water flows, avoiding and providing contingencies for process upsets, controlling spillage of ammonia based explosives, and operator training, are among the more common practices. Considering that many of the aggregates operations handle essentially inert substances, the application of PPP frequently has a significant impact on the quality of effluents produced from the sites.

SECTION 1.
INTRODUCTION

ONTARIO MINISTRY OF THE ENVIRONMENT
INDUSTRIAL MINERALS SECTOR
AGGREGATES DIVISION
BEST AVAILABLE POLLUTION CONTROL TECHNOLOGY

1. INTRODUCTION

1.1 TERMS OF REFERENCE

Kilborn Inc. (Kilborn) and The Environmental Applications Group Limited (EAG) were retained by the Ontario Ministry of the Environment (OMOE) to undertake a comprehensive study to identify Best Available pollution control Technologies (BAT) applicable to Industrial Minerals Sector effluents which are subject to monitoring under the Municipal - Industrial Strategy for Abatement (MISA) program. BAT has been defined by OMOE as a combination of demonstrated treatment technology and in-plant controls. BAT capabilities once defined, are to be used as a basis for setting effluent limits for Industrial Minerals operations. The choice of any given treatment technology or technology train, however, will be up to the individual operator, so long as the regulations are satisfied (Donyina, 1991, pers. comm.).

The Industrial Minerals Sector comprises two divisions based on product type, Non-Metallic Minerals and Aggregates. This report addresses the Aggregate Division. A separate, companion report addresses the Non-Metallic Minerals Division.

Aggregates are herein defined to include: quarries, shale and common clay, sand and gravel.

The objectives of this study are:

1) to develop an inventory of water pollution control technologies presently used at aggregate operations in Canada, the United States and Europe, focusing on design, operating conditions, performance and capital and operating costs

2) to develop an inventory of generic waste water pollution control technologies used in other industrial sectors (e.g. mining) which could be applied to aggregate operations

3) to determine, where possible, up to five technology trains which can be applied to different plant types to achieve BAT option goals

4) to estimate costs and contaminant removal efficiencies for defined BAT options

The study for applicable technologies was to focus on aggregates currently mined in Ontario, as well as 'sister' plant operations outside Ontario using demonstrated advanced technologies. 'Sister' plants are defined as, "those plants producing similar products at comparable rates to those produced by Ontario plants in the sector". (OMOE, 1991) The search was generally confined to areas with climatic conditions similar to those found in Ontario.

The process for selection of the BAT options described herein, was to consider the ability of a given, demonstrated technology to remove selected contaminants. The contaminants and parameters of primary interest within the Aggregates Division are: total suspended solids, oil and grease, ammonia/ammonium and phenolics.

In addition, consideration was to be given to the following secondary characteristics of potential BAT options:

- ability to achieve an effluent quality non-lethal to Rainbow Trout and Daphnia magna
- maximum waste water reduction by reuse and recycling
- progress towards virtual elimination of persistent toxic contaminants

For each sector and contaminant of concern, the study was to identify five BAT options (where possible) to satisfy the following criteria:

- a BAT option that utilizes the best technologies currently in use in North America, Europe, and elsewhere
- a BAT option selected by the U.S. Environmental Protection Agency (EPA) for similar plants
- a BAT option that utilizes the best technologies currently in use in Ontario
- a BAT option which produces an effluent which satisfies OMOE acute toxicity tests for Rainbow Trout and Daphnia magna
- a BAT option that advances the Industrial Minerals Sector towards the MISA goal of virtual elimination of persistent toxic contaminants.

From the obtained information a database was to be developed to summarize technical design, operating, performance and cost information for in-plant and effluent treatment technologies, and Pollution Prevention Practices (PPP).

1.2 BACKGROUND

In 1986, OMOE initiated the MISA program (Municipal - Industrial Strategy for Abatement) to strengthen the controls on water pollution from all sources. The ultimate goal of the MISA program is the virtual elimination of persistent toxic contaminants for all discharges to Ontario waterways. In order to better assess the status of water pollution in Ontario, the various industrial/municipal sources were divided into nine categories:

- Petroleum Sector
- Organic Chemical Manufacturing Sector
- Pulp and Paper Sector
- Metal and Mining Sector
- Iron and Steel Sector
- Electric Power Generation Sector
- Inorganic Chemical Manufacturing Sector
- Metal Casting Sector
- Industrial Minerals Sector

Upon promulgation of Ontario Regulation 91/90 (Effluent Monitoring Regulation for the Industrial Minerals Sector) in August 1990, a voluntary pre-regulation monitoring program was established in order to determine effluent characteristics within the sector. The pre-regulation monitoring data identified the parameters most relevant to the Industrial Minerals Sector: suspended solids, oil and grease, pH, ammonia/ammonium and phenolics.

The MISA program consists of two phases. In the first phase, sector specific effluent monitoring regulations were passed into law (e.g. Ontario Regulation 91/90). These regulations required dischargers of waste water to surface watercourses, to monitor their point source discharges at regular intervals according to specific sampling, analysis, quality assurance and quality control protocols and procedures. For Industrial Minerals Sector plants the monitoring period was August 1, 1990 to July 31, 1991.

The second phase of the MISA program involves the development and implementation of Effluent Limit Regulations for all direct dischargers in all MISA industrial sectors. The Effluent Limit Regulations for the Aggregate Division operations will be based, in part, on the capability of the BAT options identified in this study.

The Industrial Minerals Sector includes all non-fuel minerals and rocks which are mined, processed and utilized for purposes other than metal content, and as mentioned has been divided into:

i) Non-Metallic Minerals Division
ii) Aggregates Division

This document considers the BAT for the Aggregates Division only. The Non-Metallic Minerals Division is considered within the companion document, Best Available Pollution Control Technology-Industrial Minerals Sector, Non-Metallic Minerals Division.

1.3 AGGREGATES DIVISION

It is estimated that there are approximately 3,000 Aggregate producers in Ontario, of which there are approximately 100 plants which discharge effluent off-property (Donyina, 1991, pers.comm.). Twenty-four of these plants were monitored under the MISA program. For ease of both implementation of the MISA program, and future regulation, the Aggregates Division has been subdivided into three categories.

a) quarries
b) shale and common clay
c) sand and gravel

These categories are based on a combination of factors related to mineralogy, processing methods, mining methods, type of products produced and effluent contaminants.

Due to the varied nature of the Aggregates Division there are several effluent sources included under the MISA program. These sources include waste water associated with the pit or quarry, and associated manufacturing facilities. Waters related to the pit or quarry may result from surface run-off, as well as groundwater seepage into surface workings. Manufacturing related waters may include water for washing raw materials and dust suppression. The effluents monitored under MISA have been classified as:

- Quarry Water Effluent
- Storm Water Effluent
- Wash Water Effluent

The following subsections 1.3.1, 1.3.2, and 1.3.3 provide a summary of each category considered within the Aggregates Division. The summary includes the status of the Ontario industry in relation to other Canadian producers, a brief description of the process where applicable, as well as the general characteristics of the effluent released from the operation.

1.3.1 Quarries

Ontario has a large number of quarries which mine predominantly limestone. Nepheline syenite and basalt although also mined by quarrying, are considered within the Non-Metallic Minerals Division and are included within the companion document, Best Available Pollution Control Technology - Non-Metallic Minerals Division.

The majority of quarries in Ontario produce crushed stone for a wide variety of uses. Dimension stone is also produced in quarries at several locations but is not dealt with further within this report, since the processes are essentially dry, with minimal or no release of effluent off-site.

In addition to stand-alone quarries, there are also quarries found in association with non-metallic mineral producers including cement and chemical lime. These quarries are considered "captive" quarries, and as such, are considered part of the plant they supply, and are dealt with within the Non-Metallic Minerals Division.

The processing at quarries generally involves primary and sometimes secondary crushing, followed by screening of the aggregate to various size fractions. In addition, several locations in Ontario offer washed aggregate during the summer months. At these sites, washwater is generally recycled, but may be mixed with storm water prior to recirculation.

Two types of effluent streams are released by quarries in Ontario; quarry water effluent, and storm water. The characteristics of the effluent are dependant to some extent on the characteristics of the rock quarried, although generally the effluent may contain an increased concentration of suspended solids, and at times ammonia.

Within Ontario, asphalt plants are commonly associated with either crushed stone or sand and gravel operations. Asphalt producers were not considered under MISA, and as such, are not discussed within this document.

1.3.2 Shale and Common Clay

Shale and common clay (hereafter termed 'clay'), are currently used in Ontario for the manufacture of kiln-fired clay bricks. In 1984, Ontario accounted for approximately two-thirds of Canada's clay brick production (Guillet and Joyce, 1987), and historically accounts for 60% of Canada's annual clay production (OMOE 1990). There are two brick producers in Ontario which mine clay and shale as a raw material from six pits. The location of clay and shale pits in conjunction with clay brick production is controlled not only by geology, but also by the market demands. To be economically viable, it has been determined that any new brick plant must be located within approximately 80 km of Metropolitan Toronto (Guillet, and Joyce, 1987).

Due to the nature of the rock, shale and clay are removed from open pits by ripping using bulldozers or backhoes. Blasting is rarely used since the materials are soft, and upon exposure to the elements become very friable. Very little water is used in the brick making process, and any that is used (for example as a lubricant), evaporates in the kiln. Water discharge is of concern however, since natural rainwater and groundwater inputs to the pit may pick up fines, which will be released to the environment on discharge.

Effluent from the clay and shale producers consists primarily of storm water effluent from the pit. The concentration of suspended solids is the key parameter of interest at these operations.

1.3.3 Sand and gravel

Ontario is the largest producer of sand and gravel in Canada, accounting for 35% of the national production. The majority of sand and gravel produced is used in highway and building construction, concrete aggregate, and winter road maintenance. The mining equipment used in recovering sand and gravel varies from small units such as tractors, loaders and dump trucks to the larger and more sophisticated mining systems involving large power shovels, excavators and belt conveyors.

The processing of sand and gravel generally consists of washing of the sand and gravel to remove clay and silt and then screening. In certain instances however, processing may involve more complex screening and crushing operations to achieve the optimum product.

Waste water produced from washing and dust suppression generally contains elevated levels of suspended solids. Although there are a very large number of sand and gravel operations within Ontario, virtually all operations do not discharge effluent off-site. Most of the water either evaporates naturally, or seeps into the ground. As a result, the focus of the study is primarily on other aggregate producers.

1.4 PRIORITY PARAMETERS

The attached Table 1-1 identifies Priority 1 Parameters in effluents from the 23 Aggregate Division Operations monitored during the period of August 1, 1990 to July 31, 1991. This listing is based upon unedited data for which QA/QC assessment has not been completed.

Discussions with Ministry officials indicate that this preliminary listing is expected to contain all of the Priority 1 Parameters which will be determined from the final edited data. It is also expected that some of the parameters in the preliminary list will not be contained in the final list after editing and QA/QC completion.

A parameter is given Priority 1, unless a statistically determined 0.90 proportion of the data was less than RMDL (Regulation Method Detection Limit) at a 95% confidence level.

Table 1-1 summarizes the Priority 1 Parameters given in the R-15 Report for the Division, along with the number of plants showing this Priority Parameter (out of a total of 23 plants). For comparative purposes, the RMDL is listed adjacent to each parameter.

Each Priority 1 Parameter contained within Table 1-1 is briefly defined in Table 1-2 according to its source where possible, as well as whether the operations which show these parameters are significantly above the RMDL, and whether the parameter is treatable at the levels encountered. The term "not treatable at levels present" is used for those parameters and concentration levels for which the study team could not find any evidence of industrial scale treatment, applicable to Industrial Minerals Sector plants.

As a result of this listing, the document will focus primarily on the treatment of suspended solids and oil and grease.

TABLE 1-1

AGGREGATES DIVISION

PRIORITY 1 PARAMETERS LIST

(12 MONTH UNEDITED DATA FROM 23 PLANTS OF 24 PLANTS MONITORED)

No.	Parameter	Number of Plants where Parameters Selected as Priority 1	RMDL Limit mg/L (unless noted)
1	Total Suspended Solids	20	5.0
2	Oil and Grease	14	1.0
3	Specific Conductance	5	5.0 us/cm
4	Dissolved Organic Carbon (as C)	5	0.5
5	Ammonia and Ammonium (as N)	4	0.25
6	Nitrate + Nitrate (as N)	5	0.25
7	Phenolics (4AAP)	2	0.002
8	Sulphide	3	0.02
9	Fluoride	4	0.1
10	Zinc	4	0.01
11	Aluminium	4	0.03
12	Molybdenum	2	0.02
13	Cyanide	1	0.005

Note: Preliminary data available March/92 based on Download No. 1 for period August 1/90 to July 31/91

TABLE 1-2

SUMMARY OF PRIORITY PARAMETERS WITHIN THE AGGREGATES DIVISION

Parameter	Number of Plants	Possible Source	Regulated Within the Aggregate Div.	Comments
Total Suspended Solids	4 Brick 15 Quarries 1 Sand & Gravel	Process-related	Yes	Treatable at levels present
Oil and Grease	3 Brick 10 Quarries 1 Sand & Gravel	Process-related	Yes	Generally not treatable at levels present
Specific Conductance	4 Brick 1 Quarry	Natural/process-related	No	Not treatable at levels present
Dissolved Organic Carbon (DOC)	4 Brick 1 Quarry	Natural	No	Not treatable at levels present
Ammonia/Ammonium	4 Quarries	Explosive use (ANFO/ agricultural)	No	Not treatable at levels present ***
Nitrate/Nitrite	4 Brick 1 Quarry	Natural, explosive use/agricultural	No	Not treatable at levels present ***
Phenolics	1 Brick** 1 Quarry	Natural	No	Not treatable at levels present ***
Sulphide	3 Brick**	Natural	No	Not treatable at levels present
Fluoride	4 Brick	Process-related	No	Not treatable at levels present
Zinc	3 Brick 1 Quarry**	Natural	No	Not treatable at levels present*
Aluminum	4 Brick	Natural	No	Not treatable at levels present*
Molybdenum	2 Brick	Natural	No	Not treatable at levels present*
Cyanide	1 Quarry	Unknown	No	Not treatable at levels present

* Anticipate suspended solids treatment may decrease levels.

** At concentrations of close to RMDL.

*** Treated incidentally by means of natural degradation during suspended solids treatment.

1.5 SUMMARY OF STUDY METHODS

In order to identify the BAT options for effluent treatment at aggregate operations, the study team employed a technology search and evaluation methodology that was organized into a number of components. The initial task was the completion of an extensive computer database search using a variety of technical databases. The database search was employed to assemble all available published information regarding treatment technology applicable to the Aggregates Division.

This task was followed by a review of technologies currently in place at plants in Ontario, Canada, the United States, and at other producing countries with similar environmental conditions. Due to the large number of aggregate producers outside of Ontario, only selected plants were contacted. As a result, certain assumptions were made. The primary assumption of this report is that the BAT is likely to be found in a highly industrialized country with high environmental standards for pollution control. This assumption allowed energy to be focused upon potential 'sister plants' elsewhere in North America, and northern Europe.

From the plants contacted, the study team identified those operations which employed technologies that may be considered for selection as BAT. Where the study team was unfamiliar with the technology, or where further details were required, plants were visited. During the visits, the study team discussed technology performance, efficiency and costs with plant representatives.

All information collected in the data search portion of the study was collated and evaluated with respect to cost, efficiency, applicability to Ontario operations and the overall objectives of the study, in order to determine the BAT options for each category and parameter.

1.6 REPORT FORMAT

The report is presented in a hierarchial order culminating in the selection, description, and costing of recommended BAT options for pollution control. Sections 1 and 2 focus on study objectives, background, approach and data acquisition.

Section 3 provides a brief description of generic technologies potentially available to treat contaminated effluent associated with the Aggregates Division. Some of the methods described are already in common use within the industry. In addition, technologies which are still in the development stages, and technologies which are used in industries other than the aggregates industry, are also considered. The intent of this section is to familiarize the reader with technologies referenced elsewhere in the text, and to acquaint the reader with the range of possible technologies.

Section 4 provides a comparison of effluent quality standards applied to aggregate operations in the geographical areas addressed in this report.

Sections 5 and 6 focus on data acquisition and contact procedures used to develop an inventory of plant operations. Selected BAT options or preferred technologies are recommended based on the data provided within the inventory. This section focuses on those aggregates currently produced within Ontario.

BAT options are selected, described and costed in Section 7. This section is the focal point of the entire report. Generic technologies or technology trains are developed for the quarries and sand and gravel categories, as opposed to providing descriptions of the 'best plants' in existence. This allows a more meaningful approach to general costing and comparisons. General assumptions are made regarding the size, configuration, and operations of the systems to provide cost comparisons. A 'best plant' methodology was deemed to be most appropriate for the clay and shale category.

Section 8 provides a comprehensive discussion of Pollution Prevention Practices. Within the Aggregates Division, these practices may have a significant impact on effluent quality.

Section 9 summarizes of the findings of the study.

Section 10 contains a list of references made in the text of the report and a selected bibliography.

SECTION 2.

DATA SOURCES AND ACQUISITION PROCEDURES

2. DATA SOURCES AND ACQUISITION PROCEDURES

2.1 DATA SOURCES

In order to identify technologies used in plants throughout the world, the study team employed a number of information sources. These sources included: technical databases, the study team's knowledge of selected operations, discussions with site personnel and other contacts familiar with a given site's operations, aggregates category associations, U.S. EPA documentation and, in Ontario, a review of the initial reports submitted under the MISA program. The focus and methods of data collection are described in the following sections.

2.2 GEOGRAPHIC FOCUS

The terms of reference specified that the study should focus on Ontario, and those areas of the world where technological development and environmental awareness, and climatic conditions are similar to Ontario. Where climatic differences were determined not to be relevant to the functioning of a given treatment technology, the climatic restriction was ignored. In accordance with the requirement for determining applications of suitably advanced technologies, efforts were concentrated on those areas known to have high environmental and technological standards. Following this requirement, the study team focused the technology search in the following areas: Canada, northern United States, and northern Europe.

2.3 COMPUTER DATABASE SEARCH

Applicable pollution control databases were searched on-line using combinations of keywords. Keywords such as; waste water treatment, effluent treatment, mining, aggregate, best available control technology, and quarry, were used to locate publications which would apply to waste water treatment at aggregate operations.

The CAN-OLE system (Canadian On-Line Enquiry System) is the most comprehensive collection of Canadian databases. ELIAS (Environmental Library Integrated Automated System) and MICROLOG (Micromedia Catalogue System) are two of the databases searched through this network. An on-line search of the ELIAS database revealed relevant documents of the more than 20 libraries which

participate in the Environment Canada Departmental Library Network. The MICROLOG database provided access to literature and reports from all levels of Canadian government as well as universities, research institutions, laboratories, professional societies, corporations, consultants, associations and special interest groups.

Other sources of non-Canadian government documents were accessed through CODOC (Co-Operative Documents System), NTIS (National Technical Information System), ORD BBS (Office of Research and Development Bulletin Board System), and the RREL (Risk Reduction Engineering Laboratory) Treatability database. CODOC comprises the government document holdings of 11 academic libraries in Ontario. Publications from Canada, the United States, the United Kingdom, France, Germany, the USSR are included in the database. NTIS, in the United States, carries documents for distribution from over 240 U.S. government agencies. The ORD BBS and the RREL Treatability database are two U.S. EPA technical databases.

The Northern Database (Boreal - The Northern Database) and the Northern Miner Magazine Index provided information on technologies utilized in northern Ontario. Pollution Abstracts and Enviroline cover exclusively environment-related literature and provide a comprehensive index to over 5000 international publications and references on environmental literature. Technology specific to mining was searched on the IMMAGE database through the Institute of Mining and Metallurgy in London, England. Other scientific and engineering databases accessed included Scisearch, Current Technology Index, Compendex and CA Search.

2.4 SITE SPECIFIC DATA ACQUISITION

Existing plants were identified through review of various publications and personal contacts. Some of the key documents/contacts are listed below:

- Canadian Minerals Yearbook
- Clay Brick Association of Canada
- Aggregate Producer's Association of Ontario
- United States Department of Labour (MSHA publications)
- Metals and Minerals Annual Review
- Mining Annual Review
- Industrial Minerals Directory

In addition, contacts were also identified by embassies, industrial trade organizations and the study team's mining contacts world-wide. Information regarding plants was obtained by a number of means including: a review of MISA initial reports (Ontario operations only), as well as, a brief questionnaire sent to select plants, discussions with plant personnel, review of related technical articles, and site visits.

Questionnaires were developed for each of the Aggregate Division categories. The topics addressed by the questionnaire included: methods of quarrying (mining), processing operations, water use / collection on site, sewage treatment, storage of materials, methods of waste water treatment and other pollution control measures.

These questionnaires were sent to all large Ontario aggregate operations (direct dischargers only), Canadian operations, and select United States operations, excluding quarries and sand and gravel operations. Only select quarries and sand and gravel producers in Ontario were sent the questionnaire due to the large number of existing operations, and the relative homogeneity of the operations (and treatment systems). The selected operations were all direct dischargers in the case of sand and gravel producers, and in general, larger quarry operations.

Within Ontario, the questionnaire was moderately well received, and several of the respondents included information beyond what was requested. Outside of Ontario however, the response rate was very poor. Follow-up phone calls did encourage response from some of the companies approached, however, a large number of operations declined to provide information.

Where no response was received from the questionnaire (or where a questionnaire had not previously been sent), the sites were contacted directly by telephone. Where telephone follow-up was used, a sheet was developed to assist in the collation of information by study team members during discussions with site personnel. This collation sheet addressed: plant age/process technology age; process and design capacity; products; raw materials; water use/reuse/recycle; flow of waste water; technical specifications; effluent quality and effluent related regulatory requirements.

In certain instances, rather than determining the water treatment system currently in use at specific plants, manufacturers/developers of specific technologies were contacted. These contacts then provided the names and locations of plants in which their technology was currently in use. This provided another source of information outside of direct plant contacts.

The following sections describe in more detail, the identification and screening procedure according to geographic location.

2.4.1 Ontario Aggregate Operations

Simultaneous to the questionnaire survey, the study team reviewed the initial MISA reports submitted by each aggregate discharger. An inventory sheet was completed for each operation based on the information provided in the initial report, together with a summary of the effluent quality from each operation based on twelve months of data (unedited) collected during the MISA program.

Based on this review of MISA data, and the responses to questionnaires, the effluent treatment system and its effectiveness was then reviewed. The study team then selected representative or comparatively unique operations from which to collect further information (either by telephone or site visit).

Visits were conducted to three sites in Ontario, encompassing 2 of the 3 aggregate categories, and consisting of two crushed stone operations and one shale and common clay operation. In addition, during site visits associated with the development of the companion document, "Best Available Pollution Control Technology - Non-Metallic Minerals Division", quarries associated with Portland cement and chemical lime producers were surveyed.

2.4.2 Canadian Aggregate Operations Outside Ontario

A compilation of plants outside of Ontario was generated from a variety of sources. Several of the aggregate categories have associations, from which a list of member companies was acquired. Other facilities were located by use of the Canadian Minerals Yearbook, and other publications. The final source of information was from lists requested from the individual provincial governments. This final contact was the least helpful, but did provide the names of some operations. Unfortunately, there was no known listing of sand and gravel producers outside of Ontario.

A select number of operations were either requested to complete a questionnaire similar to that sent to Ontario producers, or were contacted directly. If contacted directly, an inventory sheet was filled out by the study team member during discussions. The technology information received from these two sources was then screened in a manner similar to that used for the Ontario information.

2.4.3 U.S. Aggregate Operations

Aggregate operations in the United States were identified using a listing compiled by the United States Department of Labour, Mine Safety and Health Administration (MSHA), as well as from the Industrial

Minerals Directory. The first listing included all mines and industrial mineral and aggregate producers currently active, along with their addresses, and average number of workers; while the directory provided a list and brief description of all non-metallic, non-fuel mineral producers.

Questionnaires were mailed to selected operations. Plants were selected primarily on the basis of their location (i.e. climate) and number of employees. The assumption was that locations with a negative water balance (i.e. generally southern and western locations), and a small number of employees, would be unlikely to require, or have the capital funds available to employ state-of-the-art water treatment technology. Due to the very poor response rate from the United States, select sites were contacted directly by telephone. As with the Canadian producers, a study team member completed an inventory sheet during these discussions.

2.4.4 European Aggregate Operations

Initial contact was made with the foreign embassies of selected aggregate producing countries. Based on results from these contacts, as well as a literature search applicable to the main producing countries, the principle focus was directed to: France, United Kingdom, Germany, Sweden, Norway, and Finland. This focus takes into account climatic conditions which are similar to those of Ontario, and the knowledge that these countries in general, possessed superior technology and stringent environmental regulations.

Within these selected countries, individual companies were contacted by means of the Industrial Mineral Directory. As with other companies contacted, questionnaires were completed either by the plant personnel, or by the consultants during discussions with the site. Several European sites were visited in order to develop a better understanding of some of the unique water treatment technology in use in Europe.

Differences in the languages spoken as well as a general lack of interest in international contact hampered the collection of information from overseas operations. Several operations were suspicious, or could not see a benefit to assisting in the study. This attitude derives in part from the often local nature of aggregate production and competitive marketing, which is in direct contrast to attitudes within the Metal Mining Sector where operations tend to be more international in their outlook.

No listing was available of sand and gravel producers in Europe, and as a result, the only information collected for this category in Europe is based on several site visits in the United Kingdom.

In certain instances, rather than determining the water treatment system currently in use at specific plants, manufacturers/developers of specific technologies were contacted. These contacts provided the names and locations of plants in which their technology was currently in use. Such a source supplied information on sand and gravel operations in the United Kingdom.

2.5 SITE VISITS

In order to better ascertain the effectiveness of waste water treatment technologies currently in use, site visits, as indicated above, were conducted to several operations in Ontario, as well as to operations in Germany and the United Kingdom. Visits to these operations were arranged in order to obtain a more detailed understanding of the workings of the site, the waste treatment systems in place and to obtain specific treatment data.

SECTION 3.

OVERVIEW OF AVAILABLE EFFLUENT CONTROL TECHNOLOGIES

ONTARIO MINISTRY OF THE ENVIRONMENT

INDUSTRIAL MINERALS SECTOR

AGGREGATE DIVISION

BEST AVAILABLE POLLUTION CONTROL TECHNOLOGY

3. OVERVIEW OF AVAILABLE EFFLUENT CONTROL TECHNOLOGIES

Removal technologies for water contaminants identified as primary concern by the MISA program that are present in aggregate division waste waters (suspended solids, oil and grease, ammonia/ammonium, and phenolics) are described in the following sections. The technologies are categorized according to the type of contaminant removed and are rated according to their utilization in the aggregate industry as follows:

widely used	-	a commonly used method of treatment
limited use	-	an occasionally used method of treatment
unique	-	employed at one or two related sites
pilot	-	demonstrated site performance at less than full commercial scale
potential	-	a method that could be used but is not, due to economics, performance, limited development or present use confined to other industries

3.1 SUSPENDED SOLIDS

Widely used

- settling ponds
- sumps

Limited Use

- tailings ponds
- coagulants/flocculants
- exfiltration
- passive filtration
- wetland filtration

Unique

- mechanical clarifiers

Potential

- mechanical filtration
- filtration beds

Settling Ponds (widely used)

The mechanism of solid/liquid separation in settling ponds is "free" or "ideal" settling in which solid particles settle independently of one another. The settling velocities are governed by Stoke's Law which relates particle size and specific gravity to the free settling velocity. In an engineered settling pond the area and shape of the pond is designed to reduce the solution upflow or carrying velocity to below the settling velocity of the solids particles to be settled.

principal advantages/disadvantages

- proven effective at a majority of operations
- uses local materials
- reasonable capital cost and low maintenance
- amenable to possible use of flocculants/coagulants if required
- topography may aid in reducing earthworks
- catchment of precipitation and run-off will increase total flow of effluent

The design of a settling pond is dependent upon a number of factors which include the following:

- expected range of concentration of suspended solids in the influent
- size distribution of suspended solids in the influent
- required retention time for solids settlement
- expected range of water temperature
- expected range of flow rate of the influent
- expected flow characteristics within the pond
- maximum allowable concentration of suspended solids in the effluent

Sumps (widely used)

Sumps are used to collect waste water from underground mines and quarries. Suspended solids are settled in the sump reservoir to produce an effluent suitable for discharge or further treatment. Suspended solids are periodically removed from the sump for disposal within the mine or quarry.

principal advantages/disadvantages

- required for pumping where pit and/or mine water accumulates
- no other feasible alternative
- effectiveness can be maximized through Pollution Prevention Practices
- limited settling area not always as effective as settling ponds for fines
- provides source for recycling water

Tailings Ponds (limited use)

Where wet processing of raw material is practised the reject portion of the solids in slurry form (tailings) is usually discharged into an impoundment area where solids settle and are retained. While this is the most common and primary method of tailings disposal, tailings ponds are in limited use in the aggregates division due to the fact that few operations employ wet processing. The supernatant liquid is removed using decant towers, syphon systems or barge-mounted pumps. Decant towers have to be raised as the dam wall is raised during the course of time. Barge-mounted pumps are a common method of decanting a tailings area particularly where all or most of the water is used for recycle to the process.

The size of the liquid pond required for satisfactory clarification is determined as for settling ponds.

principal advantages/disadvantages

- combined solid/liquid storage
- low maintenance costs
- large land area and water catchment
- high capital cost
- pond must be sized to provide solids storage for life of plant

Coagulants/Flocculants (limited use)

Coagulants and/or flocculants are added to solutions containing fine particles to promote the growth of larger and consequently heavier particles which have higher settling velocities. The rate of the settling process is increased resulting in a decrease in the settling area required.

principal advantages/disadvantages

- generally have not been required by the industry to date
- used in special cases where improved settling is required, or where land area for increased settling pond area is unavailable
- can be used in conjunction with mechanical clarifiers

Exfiltration (limited use)

Exfiltration is a type of natural filtration process whereby waste waters contained in settling or tailings ponds seep through earthen dams, or soils lining the bottom of the pond which act as a filtering medium. As the water seeps through, suspended solids are retained. This mechanism is effective during the initial use of the ponds, but gradually becomes less effective as the soils become clogged, allowing little or no further seepage. Effluent control and monitoring is also sometimes difficult.

principal advantages/disadvantages

- diffuse final effluent, hard to monitor
- eventual clogging
- limited effectiveness

Passive Filtration (limited use)

Passive filtration is a process whereby waste water is discharged through earthen dams or berms composed of porous aggregate materials. These materials act as a filter to remove suspended solids. This treatment method requires some maintenance to retain a porous medium by changing the discharge location or increasing the dam height. This is required due to the progressive clogging of the porous medium over time.

principal advantages/disadvantages

- achieved inadvertently at several operations, but engineered structures with this objective are in limited use
- appears to be effective at operations where used at reasonable costs
- requires maintenance to prevent pore space clogging

Wetland Filtration (limited use)

Wetlands encompass areas also known as marshes, bogs, wet meadows, peat lands, and swamps. Suspended solids are retained by filtering of suspended and colloidal material from water through the soil and organic mats.

principal advantages/disadvantages

- requires suitable geography, i.e. wetland must be well located on property
- natural wetlands often regarded as sensitive habitats
- engineered wetlands can be developed, pending land availability and suitable topography
- low capital and operating costs

Mechanical Clarifiers (unique)

This category includes conventional thickeners, reactor clarifiers and plate or tube type clarifiers. Coagulants and flocculants are generally added to facilitate the settlement of the suspended solids. The thickened product can be recycled to increase efficiency and the concentration of the suspended solids in the final sludge before disposal.

principal advantages/disadvantages

- high capital and operating costs
- allow controlled collection of sludge if disposal to another area is required

- generally require flocculant addition due to small settling area
- need surge system on feed to ensure control
- sludge disposal required

Mechanical Filtration (potential)

The separation of suspended solids from liquids by mechanical filtration is effected by the application of a pressure driving force across a physical barrier (e.g. filter cloth or porous medium) which induces the flow of liquid through the barrier. The driving force can be applied using vacuum or pressure. The filter can take many forms such as rotary drum, belt, plate or tube. Filter aids (e.g. coagulants/flocculants) and filter precoats can be used.

principal advantages/disadvantages

- high capital and operating costs
- sludge disposal required
- surge system on feed required
- generally most effective where solids concentration is high

Filtration Beds (potential)

In this method, waste water is passed through a physically restrictive medium (filtration bed) which results in the deposition of suspended particulate matter. Filtration beds are generally composed of a mixture of granular media, such as sand or anthracite. As the load of suspended solids in the bed increases, so does the head loss, necessitating backwashing. During filter backwashing, the bed is fluidized and settles with the finest particles at the top of the bed. Subsequently, most of the solids are removed from the surface of the bed. Although gravity filtration is effective, pressure filtration has the advantage of operating at higher head losses which improves capacity.

principal advantages/disadvantages

- high capital and operating costs
- sludge is dilute and may require secondary treatment
- sludge disposal required
- good removal of solids from effluent stream

3.2 OIL AND GREASE

Limited use

- gravity separation

Potential

- air flotation
- activated carbon adsorption

Waste waters contaminated with oil and grease are treated in a variety of ways. Recovery processes include gravity separation, air flotation and activated carbon adsorption. Significant concentrations of these contaminants are often associated with unique or periodic events (such as spillage) which tend to reduce the effectiveness of treatment options.

Gravity Separation (limited use)

Gravity separation is applied in the treatment of waste waters containing significant quantities of oil. The separation devices are designed to provide sufficient retention time for the oil globules to rise to the surface of the water and coalesce. Baffles are provided to retain the floating oil and allow the passage of water. Skimming devices (e.g. scrapers, slotted pipes) are required to collect the accumulated oil prior to its disposal. Gravity separators as interceptors are occasionally installed in waste water streams that may be subject to periodic surges of oil/grease related to equipment failure or spillage. Similarly, baffles or booms (with or without absorbing features) may be appropriate for pond systems to retain high concentrations of oil/grease.

Gravity separation is effective in removing and recovering unseparated emulsions and large droplets but is not as effective with finely dispersed small droplets or organic wetted particulates.

principal advantages/disadvantages

- not effective for the generally low levels (<3 mg/L) of oil and grease commonly occurring
- where required, is cost effective and requires little attention

Air Flotation (potential)

Air flotation is applied to recover organics which are finely dispersed in liquid streams and is commonly used in other industrial sectors both as a process and for effluent treatment. Oil and grease are contacted by air bubbles introduced either by air jets or as dissolved air.

The column type vertical cell is the simplest device. Finely dispersed organic solution droplets and organic wetted particulates are contacted by the rising air bubbles and carried to the surface where they are collected. Column type flotation devices do not require complex control and only require a small area for installation.

There are two principal designs of dissolved air flotation systems. In one system, the waste water is contacted with compressed air and the pressure is released in a flotation tank, generating a fine dispersion of air bubbles. In the other system, air-saturated clarified water is introduced into the flotation tank under pressure through a micro-bubble nozzle as the pressure releasing device. Oil-grease and fine suspended solids attach themselves to the bubbles and are floated to the surface where a mechanical device is used to skim off the resulting sludge.

principal advantages/disadvantages

- not effective for low levels of oil and grease in aggregate waste waters
- costs are greater than those associated with gravity separation
- sophisticated equipment and control systems required for dissolved air systems
- surge system required upstream

Activated Carbon Adsorption (potential)

Activated carbon has a high adsorption capacity for organic materials. Dissolved organics are removed by passing the liquid stream through filter beds of activated carbon or anthracite. Specific pollutants are adsorbed on to the activated carbon surface until all active sites are occupied. After saturation the carbon must be regenerated or removed and replaced. Regeneration is possible by either chemical (e.g. solvents) or thermal methods. Spent adsorbent which can no longer be satisfactorily regenerated can be disposed of in a secure landfill or by incineration.

principal advantages/disadvantages

- high capital and operating costs
- carbon retreatment or disposal required
- carbon regeneration results in transfer of removed oil and grease to either the solvent or to stack gases.

3.3 AMMONIA/AMMONIUM

Limited Use

- natural degradation

Potential

- nitrification
- break-point chlorination
- ion exchange
- air stripping
- steam stripping

Natural Degradation (limited use)

Natural degradation of ammonia occurs with the transpiration of dissolved ammonia gas from waste waters by natural means, during retention of waste waters in holding ponds for extended periods. Ammonia removal is enhanced by increasing pond surface area and aeration. The extent of removal is determined by the pH and temperature of the solution. At neutral and lower pH values, ammonia is mainly present as NH_4^+ which does not volatilize effectively.

principal advantages/disadvantages

- requires long retention times in settling/polishing ponds to be effective, and/or elevated pH to assist in ammonia volatization
- efficiency is reduced during cold weather

Nitrification - Denitrification (potential)

This method involves the biological oxidation of ammonia in a two step process. In the first step (nitrification), ammonia is converted to nitrite (NO_2) under alkaline conditions, followed by nitrite conversion to nitrate (NO_3). The second step (denitrification) involves the reduction of nitrate, to nitrogen gas and water, by contacting the solution with biological solids in the absence of oxygen at a neutral pH level. Carbon, often in the form of methanol, is added to facilitate this anaerobic process when used in the municipal sector.

principal advantages/disadvantages

- used in municipal treatment systems
- may occur naturally where suitable conditions exist in pond systems

Break-Point Chlorination (potential)

Breakpoint chlorination is a technique used to oxidize ammonia from waste waters to nitrogen gas with the production of small amounts of nitrate and nitrogen trichloride. Chlorine, in the form of chlorine gas or sodium hypochlorite, is added to perform the oxidation process. Alkaline conditions are maintained by the addition of calcium carbonate which is required to neutralize the acid produced during the

oxidation process. To eliminate hypochlorite toxicity in the treated effluent, sufficient retention time must be provided prior to discharge.

principal advantages/disadvantages

- high capital and operating cost
- chemical addition in form of chlorine is required
- residual hypochlorite possible in treated effluent

Ion-Exchange

Ammonia can be removed from waste waters by ion exchange using resins which have a chemical affinity for ammonium cations. Naturally occuring zeolite minerals are known to be more suitable than many synthetic resins. After saturation the medium must be rinsed (stripped) to remove the ammonium compounds, usually with a high pH brine solution. Filtration of the waste water prior to ion exchange may be necessary to prevent fouling of the medium by suspended solids.

principal advantages/disadvantages

- high capital and operating costs
- disposal of brine and ammonium compounds in rinse solution is required
- filtration prior to ion-exchange may be required

Air Stripping (potential)

Air stripping is typically performed in a packed bed tower with air flowing counter-current to the waste water containing the dissolved ammonia gas. The transfer of dissolved ammonia gas from the liquid to air is enhanced by the packed bed which serves to maximize the surface area of the liquid exposed to the air. A pH greater than 9 is required to maximize the ratio of ammonia to ammonium ion. As a result of the required high pH level, scaling can become an operational problem if sulphate or calcium (used for pH adjustment by the addition of lime) are present. Temperature of the water is also important, as a decrease in water temperature increases the solubility of ammonia which in turn reduces removal efficiencies.

principal advantages/disadvantages

- effective on concentrated streams
- high capital and operating costs
- not employed in the Industrial Minerals or Metal Mining Sectors

Steam Stripping (potential)

Steam stripping is essentially a fractional distillation process, conducted in a packed tower or conventional distillation column. Waste water is preheated in a heat exchanger and pumped to enter

near the top of the column. As waste water passes down the column, it is stripped by vapour rising from the bottom of the column. At the bottom of the column, solution is further heated by incoming steam to reduce ammonia to its final concentration. Heat in the waste water, discharged from the bottom of the column, is recovered by preheating the feed to the column.

principal advantages/disadvantages

- effective on concentrated streams
- high capital and operating costs
- complex equipment
- not employed in the Industrial Minerals or Metal Mining sectors

3.4 PHENOLICS

Potential

- natural degradation
- chemical oxidation
- biological oxidation
- carbon adsorption

Natural Degradation (potential)

Aeration in ponds or lagoons which provide extended retention time can result in limited phenol removal. Forced aeration is generally more effective in reducing phenol levels than is passive aeration. The mechanism for phenol removal is not well understood, but likely includes simple air stripping and degradation by biological action, possibly assisted by ultraviolet light.

Chemical Oxidation (potential)

Chemical oxidizing agents, such as chlorine dioxide, hydrogen peroxide, ozone and potassium permanganate, will react with the aromatic ring of phenolic compounds resulting in its cleavage. This cleavage produces a straight chain organic compound which can be converted to carbon dioxide and water by additional chemical oxidation, or by other treatment such as biological oxidation.

Biological Oxidation (potential)

Phenols can be biologically oxidized under aerobic conditions using heterotrophic bacteria that break down or hydrolyse organic ring compounds. Once the ring configuration is broken, the resulting straight chain hydrocarbon would be further broken down to carbon dioxide and water by bacterial activities to remove the organic matter from solution.

Carbon Adsorption (potential)

Phenolic compounds in waste water are readily removed by contact with activated carbon. The carbon adsorbs many other organic chemicals which may be present and must be regenerated or replaced when saturated.

principal advantages/disadvantages of above technologies

- none of the potential treatments identified in this section have been employed for phenolics alone in the Industrial Minerals or Metal Mining sectors
- chemical treatment implies high capital and operating costs
- natural degradation (aeration) is limited in many applications by winter conditions.

SECTION 4.

EFFLUENT QUALITY STANDARDS AND REGULATIONS

ONTARIO MINISTRY OF THE ENVIRONMENT
INDUSTRIAL MINERALS SECTOR
AGGREGATES DIVISION
BEST AVAILABLE POLLUTION CONTROL TECHNOLOGY

4. EFFLUENT QUALITY STANDARDS AND REGULATIONS

Regulatory limits applicable to the Aggregates Division in Canada, the United States and Europe are generally confined to pH and suspended solids, and less commonly to oil and grease. For a large number of individual operations in both North America and Europe, limits have not been applied. This is partly because of the age and small size of certain operations, and also because of varying administrative practices at the local (province/state) level.

4.1 CANADA - FEDERAL REGULATIONS

Although there are general provisions within the Fisheries Act prohibiting the 'deposit of a deleterious substance of any type in water frequented by fish', there are no federal regulations or guidelines for effluent limitations which apply to the Industrial Mineral Sector.

4.2 CANADA - PROVINCIAL REGULATIONS

Ontario

The province has jurisdiction over water supplies and discharges under the Ontario Water Resources Act (OWRA), the Environmental Protection Act, and other pertinent legislation. The OWRA prohibits the discharge of any material that may impair the quality of water of any well, lake, river, pond, spring, stream, reservoir or other watercourse.

The 1981 'Guidelines for Environmental Control in the Ontario Mineral Industry' have been used as a basis for determining limits. Effluent limits which are more stringent than these guidelines may be employed at newer operations. Limits at certain operations may also be set in order to meet Provincial Water Quality Objectives in the receiving water. The following guidelines are taken from the Guidelines for Environmental Control in the Ontario Mineral Industry:

pH	5.5 - 10.5
suspended solids	15 mg/L

Quebec

A Certificate of Authorization is required by all operations. The discharge limits specified within this Certificate are determined on a case by case basis. Guidelines, defined in Directive 019 - Mining Industries, are used by the Quebec Ministry of the Environment as a basis for establishing individual site limits. In most instances, the limits set are the same as the guidelines. More specific criteria for quarries and sand & gravel operations are specified in the 1991 'Regulation for Quarries and Sand Gravel Operations'. Relevant effluent discharge criteria outlined in these documents are as follows:

Directive 019

pH	6.5 - 9.5
total suspended solids	25.0 mg/L

Regulation for Quarries and Sand & Gravel Operations:

Quarries

pH	5.5 - 9.5
suspended solids	25 mg/L
oil and grease	15 mg/L

Sand & Gravel

pH	5.5 - 9.5
suspended solids	25 mg/L
oil and grease	15 mg/L

New Brunswick

Under the Water Quality Regulation of the New Brunswick Clean Environment Act, any operation which discharges a contaminant to the environment is required to obtain a 'Certificate of Approval to Operate'. In practice, and for various reasons, few operations appear to posses a Certificate of Approval. Effluent discharges are typically only regulated if there is a disturbance to a fisheries habitat downstream. A limit of 25mg/L for total suspended solids is used internally as a guide by the New Brunswick Ministry of the Environment.

Manitoba

All operations which discharge process water require a licence under the Environment Act. Effluent limits specified in the licence are primarily based on the federal Metal Mining Liquid Effluent Regulations and Guidelines. Limits are calculated from the Manitoba Surface Water Quality Objectives (July 1988) when more stringent standards are required to protect downstream uses. Applicable effluent discharge criteria from the federal guidelines are as follows:

parameter	maximum monthly mean	maximum composite sample	maximum grab sample
Total suspended solids (mg/L)	25.0	37.5	50.0

parameter	minimum monthly mean	minimum composite sample	minimum grab sample
pH	6.0	5.5	5.0

As a rule, operations with no process water discharge are not licensed.

Nova Scotia

All mining operations require an industrial permit under the Nova Scotia Environmental Protection Act. The permit specifies limits for effluent discharge, which are normally based on the federal Metal Mining Liquid Effluent Regulations and Guidelines and as dictated by site baseline information. In the future, all aggregate and sand and gravel operations will be covered under the 'Pit and Quarry Regulations' which are currently being prepared. Typical limits for total suspended solids within their Industrial Mineral and Aggregates Sector are 50 mg/L for a grab sample and 25 mg/L for a monthly mean.

Newfoundland and Labrador

Newfoundland and Labrador use the limits specified in the Environmental Control (Water and Sewage) Regulations to control the effluent discharges to sewer systems and open water. The following limits apply to discharges to open water:

pH	5.5 - 9.0
suspended solids	30 mg/L above background levels
oils (ether extract)	15 mg/L

Saskatchewan

Saskatchewan's 'Mineral Industry Environmental Protection Regulations' were created under the Environmental Management and Protection Act. All the aggregate operations require an Approval to Operate issued by Saskatchewan Environment and are governed under these regulations (Sand and gravel operations are under the jurisdiction of the Saskatchewan Energy and Mines and are therefore exempt). The only limit provided in the regulations for the discharge of effluent is for pH which should be between 6.0 and 9.5 in 75% of samples during any month, and should be between 5.0 and 10.0 for any one grab sample. Although not specified in the regulation, a total suspended solids level of between 25 and 50 mg/L is normally used by Saskatchewan Environment as a guide.

British Columbia

The Pollution Control Objectives for the Mining, Smelting, and Related Industries of British Columbia were formed under the Pollution Control Act. Discharges to water are controlled in the form of receiving water control objectives and objectives for the discharge of final effluents to marine and fresh waters. Operations which discharge process water are required to obtain a Waste Management Permit from the British Columbia Ministry of the Environment. Limits are set on a case by case basis using the Pollution Control Objectives as a guide. The following limits are the objectives for the discharge of final effluents to marine and fresh waters:

pH	6.5-8.5 - 6.5-10
total suspended solids	25 - 75 mg/L
oil and grease	10.0 - 15.0 mg/L

Alberta

A licence to operate, issued by Alberta Environment, is required for all operations under the Clean Water Act of Alberta. Effluent limitations are specified within this permit. The 'Waste Water Management Guidelines for Alberta Sand and Gravel Washing Operations' is the only published guideline for operations within the Aggregate Sector. Although operations are reviewed on a site specific basis, the following guidelines generally apply:

All Aggregate Operations	
pH	6.0 - 9.5
Sand and Gravel	
total suspended solids	35 mg/L

4.3 UNITED STATES - FEDERAL REGULATIONS

The 1979 US Development Document for Effluent Limitations Guidelines and Standards specified recommended discharge levels for aggregate producers based on Best Practical Control Technology Currently Available (BPCTCA), Best Available Technology Economically Achievable (BATEA) and New Source Performance Standards (NSPS) (Table 4-1). Although the criteria for crushed stone, and sand and gravel are included, the recommended standards for clay have not as yet been adopted into regulation.

Current minimum federal effluent limits for the aggregate sector are designated by the Environmental Protection Agency (EPA) in the Code of Federal Regulations Title 40, part 436 (1989). Any operation which discharges process water to receiving waters is required to obtain a National Pollution Discharge Elimination System Permit (NPDES permit) issued by the Regional Administrator. Certain States also have the authority to issue NPDES permits. The Regional Administrator and authorized States have the power to specify more or less stringent criteria within the permit.

The reasons for not adopting the recommended standards (1979 US Development Document) into the 1989 Code of Federal Regulation are not entirely clear, but appear to be related to: (1) a lack of immediate concern to control pollutants from non-offensive industries, (2) difficulties in expressing suspended solids loadings as a function of production rates rather than as concentrations, and (3) possible technological/cost limitations.

Effluent limits adopted in the Regulation (Code of Federal Regulations Title 40, part 436, 1989) for the applicable aggregate categories are based on the degree of effluent reduction attainable by the 'Best Practical Control Technology Currently Available '. If an operator feels that factors relating to the operation are fundamentally different from those specified in the Development Document evidence may be submitted with a request to the Regional Administrator or the State (if the State has authority to issue NPDES permits) to have alternative limits established within their NPDES Permit. If the Regional Administrator (or State) approves new limits for the operation, the limits will be established based on the degree of difference between the factors involved. New limits must ultimately be approved by the Administrator of the Environmental Protection Agency.

Limits specified in the Code (1989) are as follows:

crushed stone	pH	6 - 9
sand and gravel	pH	6 - 9

Table 4-1

Recommended Limits from the US EPA

Development Document for Effluent

Limitations Guidelines and Standards

		Suspended Solids			
		BPCTCA		BATEA - NSPS	
Category	pH	Maximum Daily Average	Monthly Average	Maximum Daily Average	Monthly Average
Quarries (crushed stone)					
* - process water	6 - 9	45 mg/L	25 mg/L	45 mg/L	25 mg/L
- mine dewatering	6 - 9	45 mg/L	25 mg/L	45 mg/L	25 mg/L
Sand and Gravel					
* - process water	6 - 9	45 mg/L	25 mg/L	45 mg/L	25 mg/L
- mine dewatering	6 - 9	45 mg/L	25 mg/L	45 mg/L	25 mg/L
Shale and Common Clay					
- mine dewatering	6 - 9	35 mg/L		35 mg/L	

* If processing is dry, BPCTCA requires no discharge

United States - State Regulations

Certain individual states (including Texas, Michigan, and New York) which meet EPA requirements have been given the authority to enforce effluent quality standards. Limits in the permits may be more or less stringent than Federal standards. In the majority of cases the limits are more stringent.

4.4 EUROPE

The Commission of the European Communities is currently undertaking studies for the purpose of developing standard effluent limits across Europe by 1992. Until that time, each European country will continue to follow their existing effluent limits.

Germany

All industries in Germany are governed by the 'Federal Minimum Effluent Guidelines to the Receiver'. This regulation requires all operations to obtain a 'Water Authorization Permit' from their applicable regional authority. Effluent discharge limits are determined within the permit on a case by case basis and are dependant upon the water quality and size of the receiving water. The limits must also be less

than those specified in any of the applicable draft guidelines. In the case of the Aggregate Division, the following limits apply under the draft Rock and Soil Industry Guidelines:

Crushed rock, and sand & gravel

Suspended solids	100 mg/L

Limestone

Suspended solids	100 mg/L
COD	150 mg/L

France

The Mining Code is the regulation which governs mining operations in France. Operations which involve on-site processing, notably cement and lime plants, are regulated under 'Law for Classified Installations'. Both of these regulations require that all operations obtain 'Authorization to Operate'. Authorizations may be acquired from the appropriate district (France is divided into over 100 districts). Limits specified within the Authorization are determined on a case by case basis. Although there are no published guidelines, the following criteria are used unofficially within the government:

pH	5 - 9
Suspended Solids	30 mg/L

United Kingdom

Under the Water Act, any operation which discharges effluent to receiving water requires a 'Consent to Discharge'. Limits stipulated in the Consent are based on an assessment of the operation in question and are generally set in order not to exceed the 'Environmental Quality Standards' (EQS) of the receiving water.

Currently, the National Rivers Authority has control of all discharges to water bodies. During the next year 'Her Majesty's Inspectorate of Pollution'(HMIP) will be taking over responsibility for regulating effluent discharges. The system will be based on the 'Best Available Technology Not Excessive Costs' (BATNEEC).

Current typical limits for total suspended solids on discharges from clay operations vary widely from 100 mg/L to 2000 mg/L, however, most plants must meet a limit of 250 mg/L. A pH of between 3.0 - 8.0 is typical. It is anticipated that a typical total suspended solids limit of 125 mg/L and a pH range of 6 - 9 will be required next year when the new system is in place. A new turbidity limit may also be introduced at that time.

4.5 SUMMARY - REGULATIONS

Following a review of legislation and guidelines with respect to the Aggregates Division to date, specific limit regulations pertaining to all sub-sectors of the Aggregates Division have not been fully developed. Also, apart from some specific sub-sector applications in several jurisdictions, limits are associate with general guidelines covering all industrial operations or discharges, and/or guidelines which cover all mineral producers including metal mines.

The key parameters discussed with respect to regulations applied to the Aggregates Division are pH, oil and grease and suspended solids. pH considerations are very similar under all jurisdictions with limits generally defined at a lower limit of 6.0 - 6.5 and an upper limit of 9-10.5. In comparison to the other jurisdictions reviewed, currently Ontario exhibits the greatest pH range from 5.5 - 10.5. Limits for oil and grease are less commonly defined but typically are 10-15 mg/L for most jurisdictions.

Ontario's Mineral Industry Effluent Guidelines incorporate the most stringent limits for suspended solids as compared to all other jurisdictions reviewed. Table 4-2 provides the comparative limits currently legislated or proposed in Canadian, U.S. and overseas locations. The basis for defining the various limitations relates to factors including expected toxicity in receiving waters, and/or other contaminates associated with suspended solids. The basis of the limits defined in Ontario relates to the Mineral Industry Effluent Guidelines. These guidelines were developed with a greater focus and application to metal mines. As a result, the suspended solids concentrations have been minimized due to the expectation that the solids may be composed of contaminants such as heavy metals, which may further enhance the toxicity of the effluent.

Suspended solids associated with aggregate operations are however, generally composed of inert rock and soil particles. Thus, the toxicity related to suspended solids within the aggregate industry may have greater flexibility with respect to the current limitation of 15 mg/L and in most cases, depending upon the sensitivity of receiving water, limits may more appropriately be defined by other jurisdictions as listed in Table 4-2.

Table 4-2

Comparative Regulatory Limits/Guidelines - Suspended Solids

Jurisdiction	Suspended Solids Limits/Guidelines (mg/L)
1) Ontario	15
2) Quebec	25
3) New Brunswick	25
4) Manitoba	25 (Monthly Mean)
5) Nova Scotia	25 (Monthly Mean)
6) Newfoundland/Labrador	30 (Above Background)
7) Saskatchewan	25-50
8) Alberta	35 (Sand and Gravel)
9) British Columbia	25-75
10) Canada	25 (Metal Mining)
11) United States (Federal)	-
12) France	30
13) Germany	100
14) United Kingdom	250

Table 4-2 summarizes the limits or guidelines applied to Aggregate operations. The table is provided for comparison purposes only, since limits and guidelines are not equivalent in implementation.

SECTION 5.

SCREENING OF WORLD WIDE OPERATIONS

ONTARIO MINISTRY OF THE ENVIRONMENT
INDUSTRIAL MINERALS SECTOR
AGGREGATES DIVISION
BEST AVAILABLE POLLUTION CONTROL TECHNOLOGY

5. SCREENING OF WORLD WIDE OPERATIONS

A compilation of aggregate operations within the primary countries of interest (Canada, United States, United Kingdom, France and Germany), was developed by means of various contacts and sources. These included the review of various industry publications and the use of personal contacts. Some of the key documents/contacts, and the countries they refer to, are listed below:

Canada:	Canadian Minerals Yearbook Canadian Mines Handbook
United States:	United States Department of Labour (MSHA publications)
Worldwide:	Metals and Minerals Annual Review Mining Annual Review Industrial Minerals Directory

In addition, operations were also identified through contacts with government offices or embassies overseas, as well as industrial trade organizations.

The screening of each of Ontario, other Canadian, United States, and European aggregate operations is discussed below.

5.1 ONTARIO AGGREGATE OPERATIONS

A list of Ontario Aggregate producers was originally developed primarily by use of MISA documentation. These documents provided a comprehensive list of all shale and common clay producers, a large number of quarries, and select sand and gravel operations currently in production which discharge effluent off-site.

A questionnaire was developed for each of the aggregate operations. Topics addressed by the questionnaire included: methods of quarrying (mining), processing operations, water use / collection on

site, sewage treatment, storage of materials, methods of water treatment and other pollution control on site. These questionnaires were sent to all shale and common clay producers, and a select number of other aggregate operations, in order to obtain information which was not necessarily contained within the MISA initial reports.

This questionnaire was moderately well received, and several of the respondents included information beyond that which was requested. Follow-up phone calls encouraged response from some of the companies approached.

Simultaneous to the questionnaire survey, the study team reviewed the initial reports submitted under the MISA program by each aggregate direct discharger. An inventory sheet was completed for each operation based on the information provided in the initial report. A summary of effluent quality from each operation was also completed based on the twelve months of data (unedited) collected during the MISA program.

Where no response was received from the questionnaire (or where no questionnaire had previously been sent), the sites were contacted directly by telephone. A sheet was developed to assist in the collation of information by study team members during telephone discussions with site personnel. This collation sheet addressed: plant age/process technology age; mining and process technology; products and capacity; water use/reuse/recycle; waste water treatment; technical specifications; effluent quality.

Based on the review of MISA data, and responses to questionnaires, the effluent treatment system and its effectiveness was then evaluated. The study team then selected representative or unique operations from which to collect further information (either by telephone or site visit).

Site visits were conducted to 3 sites in Ontario, encompassing two of the aggregate categories. One shale and common clay producer was visited, as well as two quarries. These sites were chosen based upon several different factors including: the quality of effluent currently being achieved; the waste water treatment technology in use; and in some instances, the application of Pollution Prevention Practices during day-to-day operations. These visits should not be construed as defining the 'best plants' in Ontario, since the visits were for fact-finding purposes only.

The aggregate operations visited in Ontario are listed below:

Category	Company Name	Location
Shale and Common Clay	Brampton Brick	Cheltenham
Quarries	Dufferin Aggregates	Milton
	Eglinburg Quarry	Kingston

During the site visits, the operators kindly provided a tour of facilities, and detailed information beyond that which could be obtained through questionnaires, published documents, and telephone conversations.

5.2 OTHER CANADIAN AGGREGATE OPERATIONS

A list of plants outside of Ontario was generated from various sources, including aggregate associations, the Canadian Minerals Yearbook, and other publications. Additional plant listings were provided by various provincial governments. In general, there was a difficulty in locating quarries, and sand and gravel operations outside of Ontario, and comprehensive lists could not be obtained.

Select operations throughout Canada were contacted for the purpose of inventory development. The operations were chosen based upon a variety of factors including whether the operations could be considered 'sister plants' to Ontario operations. The choice of operations was also based upon the experience and knowledge of Canadian operations by Kilborn and EAG (including that of branch offices and related companies), as well as a review of relevant publications and discussions with various individuals and companies.

These selected operations were either requested to complete a questionnaire similar to that sent to Ontario producers, or were contacted directly by telephone. If contacted directly, an inventory sheet was filled out by the study team member during telephone discussions.

Since Ontario is the largest aggregate producer in Canada, the focus was placed upon Ontario producers. Operations were contacted within the other provinces although response rate varied. No operations were contacted within the northern Territories due to the difference in climate, and the lack of aggregate production.

5.3 UNITED STATES AGGREGATE OPERATIONS

Aggregate operations in the United States were identified using a listing compiled by the United States Department of Labour, Mine Safety and Health Administration (MSHA). This document lists all mines, industrial mineral producers and most aggregate operations currently active, along with their addresses, and average number of workers.

Due to the large number of aggregate operations, only a select number of operations were contacted. These operations were selected primarily on the basis of their location, and the number of employees. The assumption is that locations with a negative water balance (ie. generally southern and western locations), and those with a small number of employees, would be unlikely to require, or have the capital funds available to employ either state-of-the-art or any other waste water treatment technology. In general, southern and western operations have the opportunity to operate with 'zero volume discharge' taking advantage of high evaporation potentials relative to precipitation.

After the sites were selected, questionnaires similar to those used in Canada were mailed. Due to the very poor response rate from the United States, a selection of the sites initially mailed to, were contacted directly by telephone. As with the Canadian producers, a study team member completed an inventory sheet during these discussions. A surprisingly large number of the operations contacted directly refused to comment, or offered to provide only a limited amount of information. As a result, the inventories of United States aggregate operations are less detailed than those of Canadian operations.

The aim in contacting United States operations was to obtain an overview of current water treatment technologies, rather than to contact every site. Those operations which were contacted by telephone were asked if they knew of more sophisticated treatment technologies, however, no new technologies were found by this method.

5.4 EUROPEAN AGGREGATE OPERATIONS

European contacts were restricted to 'western' Europe, and focussed primarily on Germany, France, and the United Kingdom. These areas are broadly similar to Ontario in terms of technological development, environmental awareness, and climate. Contacts outside of these major producing areas were not attempted, principally because there is little evidence to suggest that the pollution control technologies employed would be likely to represent an advance over other areas contacted.

Initial contact was made with the foreign embassies of various countries in western Europe in order to receive information on the status of aggregate production within their respective countries. Individual

companies in each country were then contacted by means of either the information obtained through the embassy and other contacts, or from the Industrial Mineral Directory. As with companies contacted in other areas of the world, questionnaires were completed either by plant personnel, or by the study team members during discussions with the site personnel. These questionnaires provided the information for the inventory of waste water treatment technologies.

Unfortunately, communication difficulties as well as a general lack of interest regarding international contacts, impeded the collection of information from overseas operations. Operations were not always cooperative, or could not see that they would benefit in any way by assisting in the study.

In order to develop a better understanding of some of the unique water treatment technology in use in Europe for the treatment of suspended solids, a select number of European sites were visited. In particular, the focus of the trip was on specialty clay producers within the United Kingdom and Germany, since these operations may have the most severe problem of suspended solids removal. Two sand and gravel operations were also toured during the visit to Europe.

SECTION 6.
INVENTORY OF SELECTED PLANT OPERATIONS

6. INVENTORY OF SELECTED PLANT OPERATIONS

This section provides a summary of the processing and effluent treatment technologies currently employed within the various aggregate operations. The focus has been placed on Ontario operations, however, information has also been obtained where possible, from other Canadian, United States and European operations.

At aggregate operations which were receptive, general information could be obtained regarding quarring and processing techniques employed, as well as methods of effluent treatment. Outside of Ontario, only rarely could information be obtained regarding the specifics of the effluent treatment system, or the levels achieved. This information was either not available at the site, could not be released to the consultants, or in the case of effluent quality, had not been tested. At none of the operations contacted was information available regarding the toxicity of the effluent, although general comments regarding the presence of fish within the settling pond / sump system were noted.

The inventory summaries are organized according to whether the aggregate is currently being produced in Ontario, or whether there are potentially economically feasible deposits which may come into production at some point in the future. Further information regarding specific sites can be obtained from tables at the end of the section. Most sites are not identified specifically due to a preference from the operations to remain unnamed.

6.1 CURRENT PRODUCERS

Quarries

Ontario has a large number of quarries which mine predominantly limestone. Processing at quarries generally involves primary and sometimes secondary crushing, followed by screening of the aggregate to various size fractions. In addition, several locations in Ontario offer washed aggregate during the summer months. At these sites, washwater is generally recycled, but may be mixed with surface run-off and groundwater prior to recirculation.

Effluent treatment, where present, generally involves gravity settling of solids from solution by use of either a sump or pond located in the sink of the quarry. The complexity of the system, to some extent, appears to be a function of the size of the quarry, and hence the amount of water which must be discharged.

At several sites, complex systems of ponds and sumps have been developed in order to ensure that suspended solids have an adequate opportunity to settle prior to discharge. At Dufferin Aggregates at Milton, for example, a series of three settling ponds, a surface drainage pond, and five sumps are all joined into one effluent system. At smaller quarries a system as complex as this is not required nor implemented.

Shale and Common Clay

There are six operations in Ontario which produce shale and common clay from open pits for use in brick manufacture. At these pits, shale is ripped from the sides of the pit, using bulldozers or backhoes. Blasting is rarely used since the materials are soft, and upon exposure to the elements become very friable. Very little water is used in the brick making process, and any that is used (for example as a lubricant), evaporates in the kiln.

Effluent from these plants consists primarily of surface run-off from the site, as well as direct precipitation. This water may pick up fines from the working face or stockpiles, and as a result, may contain a high concentration of suspended solids. Treatment typically consists of settling in the base of the pit in a naturally occurring pond.

One producer however, Brampton Brick at Cheltenham, has developed a system whereby all surface drainage is collected in a settling pond with an internal brick filter, and is then pumped to a decant pond system for further settling. The settling pond is designed to provide a minimum retention time of 48 hours (based on a 6 hour, 2 year storm event). Although the system is a recent development, it is anticipated that by recycling the effluent for dust control and washing, the amount of effluent can be controlled, and therefore discharge off-site would occur only once or twice per year.

At other Canadian shale and common clay producers contacted outside of Ontario, the effluent also resulted from surface or ground water inputs, or precipitation directly into the pit. The method of treatment is similar to the majority of Ontario producers, that being collection of the water in a sump or pond at the sink of the pit, and pumping off-site as necessary to keep the pit dry.

The majority of producers contacted in the United States have similar systems for treatment, i.e. collection of drainage in the base of the pit and pumping off-site as required. One site that was contacted employed a method of pit development which aided in this process. While developing the six pits currently in production, the producer ensured that the base of the pits sloped a few degrees in one direction. This, along with the placement of swales as required ensured a dry face, while minimizing traffic through the water, and allowing water to collect in one location. This water was then allowed to either seep out into the ground or evaporate. No effluent is discharged off-site.

Due to the nature of the clay and shale industry, that is, the smallness of the operations, and their captive nature, no European producers were contacted. Information collected regarding the water treatment of "specialty clays" in Europe however also applies to the shale and common clay category.

Sand and gravel

The processing of sand and gravel in Ontario generally consists of washing the coarse material to remove clay and silt, followed by screening to size. In certain instances however, processing may involve more complex screening and crushing operations to achieve the optimum product. Waste water produced from washing, non-contact cooling and dust suppression, is generally treated using settling ponds. Recycling of water from these ponds has allowed all sand and gravel producers in Ontario except one to become non-dischargers.

Similar circumstances were reported at operations contacted elsewhere in Canada, and in the United States. The accepted practice within the industry is to settle wash water effluent in ponds, and then recycle the water. Natural seepage through the base of the settling pond (usually an unused pit) ensures that the pond does not overflow. Published information indicates that in the United States, flocculants may be used to increase the rate of settling if required.

Two sand and gravel operations in the United Kingdom were toured during the visit to Europe. Due to the depletion of clean deposits at some time in the past, typical producers have a much higher content of fines within their deposits than appear to be present in the active deposits in Ontario. As a result, sand and gravel produced within the United Kingdom is washed. The washwater generally has a higher concentration of suspended solids than at Ontario operations. In order to reduce the high level of suspended solids prior to recirculation of the water back to process, the operations employed a degritter system. This technology although effective enough to allow the recirculation of the washwater, would not be able produce an effluent quality acceptable for discharge.

None of the producers in the United Kingdom contacted discharge effluent off-site.

Asphalt

Within Ontario, asphalt plants are commonly associated with either crushed stone or sand and gravel operations, since these aggregates are the principle raw material of asphalt. Sized aggregate is mixed with asphalt in either a pug mill or drum mixer in order to produce a hot asphalt mixture. Asphalt is most commonly used for road paving.

Although there is no process water directly associated with the asphalt process, there may be water released from wet scrubbers. Wet scrubbers were commonly used by asphalt plants 10 years ago but have since been almost completely replaced by baghouses which do not generate any water discharges. Where wet scrubbers are used a cooling/settling pond is required in order to facilitate water recycle.

6.2 SUMMARY OF PERFORMANCE OF WASTE WATER TREATMENT FACILITIES

Table 6-1 summarizes the waste water treatment technologies in use throughout Ontario, Canada, the United States and Europe, and their effluent performance data where available. The effluent performance data for the Ontario producers was obtained from the Ontario MISA monitoring program in which water quality testing was performed over a period of one year, from August 1990 to July 1991. At the time of printing, only unedited monitoring data which had not undergone QA/QC, was available. As a result, although the trends within the monitoring data are likely correct, individual values listed in Table 6-1 may require amendment after final editing of data.

Performance of the treatment technologies may be evaluated from this monitoring program. Although many parameters were monitored in the MISA program, Table 6-1 focuses on 5 main parameters presented as long term average (LTA) concentrations. Performance data for operations outside of Ontario will not be discussed because of a lack of information.

The treatment of waste water in the Aggregates Division is directed almost solely at the control of suspended solids. Treatment technologies comprise either sumps or sumps in series, or settling ponds (in or out of series).

The LTA effluent performance data for the various quarries in Ontario indicate a range of concentrations of suspended solids of 4.2 mg/L to 113 mg/L. The pH of the quarry water is generally alkaline, with levels between 7.45 to 8.13. Concentrations of oil and grease are approximately 1 mg/L, but were

recorded as high as 3.77 mg/L. Phenolics are generally between 0.8 μg/L and 2.71 μg/L, with one reported case of 8.67 μg/L. Ammonia levels are below 0.65 mg/L.

Waste water from shale and clay producers is comprised mainly of surface run-off. Suspended solids in the discharge from settling ponds which treat the process water, range from 48.4 mg/L to as high as 283.3 mg/L. The water is alkaline, with pH ranging between 7.71 to 8.34. Oil and grease concentrations average 1.3 mg/L. Phenolics concentrations are between 1.0 and 1.8 μg/L. Ammonia levels generally range between 0.04 and 0.08 mg/L, with one operation reporting a LTA of 0.24 mg/L.

A newly developed shale and clay pit which was not monitored under the MISA program, had a single effluent discharge during 1991 which had a pH of 7.8, suspended solids concentration of 1.6 to 8.0 mg/L and phenolics concentration of 1.0 μg/L.

Only one sand and gravel producer releases effluent off-site. Based on six months of data only, water quality from this producer indicates pH averaging 7.89. The suspended solids concentration obtained was 28.1 mg/L. Phenolics were comparatively high, at 6.67 μg/L.

The wide range of concentrations of the priority parameters, between the individual aggregate producers, can be attributed to variations in site conditions, surface and ground water volume contribution, raw materials and the degree of water recycle. Many of the settling ponds used within the industry are non-engineered structures and have generally been developed without regard to pond sizing, particle settling characteristics, short circuiting and other factors.

<u>Toxicity</u>

Preliminary toxicity data for the Aggregates Division are also summarized within the inventory sheets that follow (Table 6-1). None of the effluents monitored within the Aggregates Division were considered toxic to Daphnia magna or Rainbow Trout, based on 48 hour and 96 hour LC50 tests respectively.

TABLE 6-1 : INVENTORY OF SELECTED AGGREGATE OPERATIONS

NAME	LOCATION	AGE (a)	TYPE OF MINE	HOW MINED	STEPS IN PROCESS	WATER USES AND RATE	WATER RECYCLE	EFFLUENT TREATMENT TECHNOLOGY	FLOW RATES	OTHER POLLUTION CONTROL	TOXIC	EFFLUENT QUALITY pH	s.s. mg/L	O & G mg/L	phenolics ug/L	NH3/NH4 mg/L
SUB-HEADING - SHALE AND COMMON CLAY IN ONTARIO																
1. Brampton Brick	Cheltenham, Ont.	1	Open pit	ripping	1.crushing	dust suppression, 35 m3/d	yes	settling pond with brick filter, also decant pond	one discharge 12 000 m3/a	dust filter in storage dome	NO	7.83	1.6 to 8.0 (not MISA data)	-	1.00	-
2. Canada Brick	Burlington, Ont.	33	Open pit	ripping	1.crushing 2.milling 3.screening 4.brickmaking	process water, 189 m3/d	-	settling pond	306 m3/d	-	NO	7.96	283.3	1.06	2.30	0.24
3. Canada Brick	Cooksville, Ont.	80	Open pit	ripping	1.crushing 2.milling 3.screening 4.brickmaking	process water	-	settling ponds	636 m3/d 819 m3/d	-	NO NO	8.17 8.12	69.4 173.8	1.40 1.03	1.44 1.56	0.04 0.07
4. Canada Brick	Gloucester, Ont.	30	Open pit	ripping (occ. ANFO)	1.crushing 2.milling 3.screening 4.brickmaking	process water	-	settling pond	2324 m3/d	-	NO	8.34	103.2	0.96	1.80	0.05
5. Canada Brick	Streetsville, Ont.	80	Open pit	ripping	1.crushing 2.milling 3.screening 4.brickmaking	process water, 132 m3/d	-	settling pond	538 m3/d	-	NO	7.71	48.4	1.84	1.00	0.08
SUB-HEADING - SHALE AND COMMON CLAY IN CANADA OUTSIDE OF ONTARIO																
1.	Edmonton, Alberta	-	Open pit	ripping	1.crushing 2.brickmaking	process water, 400 m3/a	-	none, no process effluent	-	-	-	-	-	-	-	-
2.	Abbotsford, B.C.	-	Open pit	ripping (some ANFO)	1.crushing 2.brickmaking	process water	-	sent to sewer	-	air emission control	-	-	-	-	-	-
3.	Beauport, Quebec	-	Open pit	ripping	1.crushing 2.screening 3.brickmaking	-	-	collected in sump	-	-	-	-	-	-	-	-
4.	Albion, B.C.	-	Open pit	loaders	1.crushing 2.scrubbing	washing aggregate, 1.7 m3/min	yes	settling in 5 ponds	-	-	-	-	-	-	-	-

TABLE 6-1 : INVENTORY OF SELECTED AGGREGATE OPERATIONS

NAME	LOCATION	AGE (a)	TYPE OF MINE	HOW MINED	STEPS IN PROCESS	WATER USES AND RATE	WATER RECYCLE	EFFLUENT TREATMENT TECHNOLOGY	FLOW RATES	OTHER POLLUTION CONTROL	TOXIC	EFFLUENT QUALITY pH	s.s. mg/L	O & G mg/L	phenolics ug/L	NH3/ NH4 mg/L
SUB-HEADING - SHALE AND COMMON CLAY IN USA																
1.	Edwardsville, Illinois	10	Open pit	dragline	shipped offsite	none	no	pond at base of pit	-	-	-	-	-	-	-	-
2.	Denver, Colorado	19	Open pit	-	shipped offsite	none	no	pond at base of pit	-	-	-	-	-	-	-	-
3.	Boulder, Colorado	40	Open pit	scrapers	shipped offsite	none	yes, offsite	pond at base of pit	-	-	-	-	-	-	-	-
4.	Castle Rock Colorado	-	Open pit	scrapers	shipped offsite	none	no	pond at base of pit	-	pit designed to drain to one side. water evaporates naturally	-	-	-	-	-	-
SUB-HEADING - CLAY IN EUROPE																
1. Fuchs'sche Tongruben	Westerwald Region, Germany	30	Open pit	backhoe	1.crushing	vehicle washing dust suppression	yes	settling pond with diffusers and oil skimmer	-	oil and gas seperators and coalescers		regulation s.s.=100 ppm, normal level is 250				
2. ECC	St.Austell England	200	Open pit	high powered monitor	1.refining 2.dewatered 3.crushing 4.screening	various catchment and settling ponds at different locations	yes	oil absorbents (booms, pillows, rails) one site is developing a treatment plant	-	-		regulation s.s.=250 and pH 3 to 8 expected to change to 100 and 6 to 9 typical operating figure is 85 , but can reach 4 000.				
3. WBB	Newton Abbot, England	300	Open pit	small shovel	1.crushing 2.blending 3.screening	none	no	sump and 2 settling ponds	-	-		<500 regulation=50, range 30 to 60 varies from site to site				
4. Steetley Minerals	Notts., England	50	Open pit	high powered monitor & ripping	1.cyclone 2.filtration 3.drying	scrubber	-	2 settling ponds	-	-		-	-	-	-	-

TABLE 6-1 : INVENTORY OF SELECTED AGGREGATE OPERATIONS

NAME	LOCATION	AGE (a)	TYPE OF MINE	HOW MINED	STEPS IN PROCESS	WATER USES AND RATE	WATER RECYCLE	EFFLUENT TREATMENT TECHNOLOGY	FLOW RATES	OTHER POLLUTION CONTROL	TOXIC	EFFLUENT QUALITY pH	s.s. mg/L	O & G mg/L	phenolics ug/L	NH3/NH4 mg/L
SUB-HEADING - QUARRIES IN ONTARIO																
1. Amherst Quarries	Amherstburg, Ont.	-	Open pit	blasting	1.crushing 2.screening	dust suppression, 23 m3/d	no	settling in 3 settling ponds	1539 m3/d	-	NO	7.59	12.6	2.88	0.80	0.13
2. Boyce Quarry	Ottawa, Ont.	-	Open pit	blasting	1.crushing 2.screening 3.asphalt plant	washing dust suppression	yes	settling in 2 settling ponds	2878 m3/d	dust control on asphalt plant	NO	8.12	5.0	0.98	2.25	0.21
3. Gormley Aggregates	Carden Twp., Ont.	14	Open pit	blasting	1.crushing 2.screening 3.washing	washing dust suppression	no	settling in 2 settling ponds	275 m3/d	liq. CaCl for road dust suppression	NO	7.92	10.6	1.15	1.16	0.50
4.Permanent Concrete	Cornwall, Ont.	-	Open pit	-	-	-	no	settling pond	1835 m3/d	-	NO	8.03	7.9	1.00	2.25	0.23
5.Tomlinson Quarry	Nepean, Ont.	-	Open pit	-	1.crushing 2.screening	dust control	no	sump	663 m3/d	-	NO	8.09	14.1	1.10	2.20	0.56
6. Flamboro Quarry	Dundas, Ont.	-	Open pit	ANFO blasting	1.crushing 2.washing	washing	yes	collection in sump	1921 m3/d	-	NO	7.45	11.3	2.44	0.80	0.15
7. Francon	Ottawa, Ont.	-	Open pit	blasting	1.crushing 2.screening	concrete plant, 26,000 m3/a asphalt plant, 3 500 m3/a watering stockpiles, 20 000 m3/a dust suppression, washing equipment	-	settling in 2 settling ponds and 2 sumps	2025 m3/d	dust collectors	NO	8.14	8.7	1.00	2.42	0.23
8. Law Crushed Stone	Port Colborne, Ont.	54	Open pit	ANFO blasting	1.crushing 2.screening 3.washing	washing	-	settling in 2 settling ponds and 1 sump	14 088 m3/d	-	NO	7.91	4.2	1.41	1.34	0.22
9. L'Original Quarry	L'Original Ont.	-	Open pit	blasting	1.crushing 2.screening	dust supression	-	settling in 2 settling ponds	1152 m3/d	-	NO	8.09	46.1	1.00	3.14	0.32
10. McLeod Quarry	Cornwall, Ont.	32	Open pit	blasting	1.crushing 2.screening	-	no	settling pond,	587 m3/d	-	NO	8.04	4.3	1.00	2.71	0.26
11. Milton Limestone	Milton, Ont.	-	Open pit	blasting	1.crushing 2.screening	washing stone washing equipment dust supression	no	settling pond,	493 m3/d	glycols, oil, scrap, garbage removed from site	NO	aquatic life in effluent 7.74	6.3	2.19	1.29	0.07
12. Nelson Quarry	Burlington, Ont.	37	Open pit	ANFO blasting	1.crushing 2.screening	-	no	settling in settling pond and 4 sumps	9210 m3/d 4622 m3/d	-	NO	7.69 7.86	113.0 14.4	1.37 1.24	0.94 1.00	0.65 0.04
13. Richier Quarry	Cornwall, Ont.	8	Open pit	blasting	1.crushing 2.screening	-	no	settling pond	565 m3/d	-	NO	8.11	4.5	1.00	2.00	0.22

TABLE 6-1 : INVENTORY OF SELECTED AGGREGATE OPERATIONS

NAME	LOCATION	AGE (a)	TYPE OF MINE	HOW MINED	STEPS IN PROCESS	WATER USES AND RATE	WATER RECYCLE	EFFLUENT TREATMENT TECHNOLOGY	FLOW RATES	OTHER POLLUTION CONTROL	TOXIC	EFFLUENT QUALITY pH	s.s. mg/L	O & G mg/L	phenolics ug/L	NH3/NH4 mg/L
SUB-HEADING - QUARRIES IN ONTARIO (cont'd)																
14. Ridgemount Quarries	Thorold, Ont.	-	Open pit	blasting	1.crushing 2.screening	washing equipment dust suppression	no	settling pond in quarry floor	4379 m3/d	-	NO	7.91	6.5	1.31	1.49	0.06
15. Uhtoff Quarry	Burlington, Ont.	-	Open pit	-	1.crushing 2.screening	-	no	settling pond	8792 m3/d	-	NO	8.07	7.7	1.38	1.26	0.09
16. Allan G. Cook Ltd.	Coldwater, Ont.	24	Open pit	blasting	1.crushing 2.screening 3.sizing	washing equipment dust suppression 19 to 38 m3/week	-	settling ponds	254 m3/d	-	NO	7.77	5.0	3.77	0.98	0.09
17. Vineland Quarries	Thorold, Ont.	-	Open pit	blasting	1.crushing 2.screening 3.sizing	washing aggregate washing sand products washing equipment dust suppression	yes	settling pond	-	-	-	-	-	-	-	-
18. Standard Aggregates	Markham, Ont.	-	Open pit	-	-	dry operation	-	-	-	-	-	-	-	-	-	-
19. Cruickshank Const.	Frontenac, Kingston, Elginburg Ont.	-	Open pit	blasting	1.crushing 2.screening 3.stockpiling	dry operation	-	-	1079 m3/d	-	NO	Elginburg Quarry 8.13	5.1	1.00	8.67	0.26
20. Halton Crushed Stone	Agincourt, Ont.	33	Open pit	blasting	1.crushing 2.screening 3.washing	378 m3/d	yes	collection in 2 sumps	90 720 m3/d	-	-	-	-	-	-	-
21. Queenston Quarries	Niagara Falls, Ont.	137	Open pit	blasting	1.crushing 2.screening	dry operation	-	-	-	-	-	-	-	-	-	-
22. Walker Bros.	Thorold, Ont.	104	Open pit	blasting	1.crushing 2.screening	washing, 265 m3/h	yes	settling in 3 ponds, all recycled, no effluent	-	-	-	-	-	-	-	-
24. Standard Aggregates	Brechin, Ont.	16	Open pit	blasting	1.crushing 2.screening	dry operation	no	-	-	-	-	-	-	-	-	-
25. James Dick Const.	Brechin, Ont.	13	Open pit	ANFO blasting	1.crushing	dust suppression	no	2 sumps	-	-	-	-	-	-	-	-
26. Cayuga Materials	Cayuga, Ont.	36	Open pit	blasting	1.crushing 2.screening 3.washing	washing aggregate dust suppression	yes	settling in 2 ponds	-	-	-	-	-	-	-	-
27. Nelson Aggregate	Beamsville, Burlington, Orillia, Ont.	- 40 83	Open pit	blasting	1.crushing 2.screening	washing equipment dust suppression washing material (Beamsville)	yes (Beamsville location)	settling in 5 ponds	-	-	-	-	-	-	-	-

TABLE 6-1 : INVENTORY OF SELECTED AGGREGATE OPERATIONS

NAME	LOCATION	AGE (a)	TYPE OF MINE	HOW MINED	STEPS IN PROCESS	WATER USES AND RATE	WATER RECYCLE	EFFLUENT TREATMENT TECHNOLOGY	FLOW RATES	OTHER POLLUTION CONTROL	TOXIC	EFFLUENT QUALITY pH	s.s. mg/L	O & G mg/L	phenolics ug/L	NH3/NH4 mg/L
SUB-HEADING - QUARRIES IN ONTARIO (cont'd)																
28. Port Colborne Quarries	Port Colborne, Ont.	33	Open pit	ANFO blasting	1.crushing 2.screening	washing material	-	settling in 2 ponds	-	-	-	aquatic life evident				
29. Dufferin Aggregates	Milton, Ont.	30	Open pit	ANFO blasting	1.crushing 2.screening 3.some washing	dust suppression aggregate washing, 20 m^3/min	yes	settling in 3 ponds and 5 sumps	7572 m^3/d	-	NO	aquatic life evident 7.45	5.7	2.30	0.80	0.09
SUB-HEADING - QUARRIES IN CANADA OUTSIDE OF ONTARIO																
1.	St.John, New Brunswick	-	Open pit	blasting (gel)	1.crushing 2.screening	washing vehicles dust suppression washing rocks	-	settling pond	-	dust collectors	-	-	-	-	-	-
2.	Fredericton, New Brunswick	30	Open pit	-	-	dry operation	-	none	-	-	-	-	-	-	-	-
3.	Moncton, New Brunswick	-	Open pit	blasting	1.crushing 2.screening	washing vehicles dust suppression washing aggregate	yes	settling pond	-	-	-	-	-	-	-	-

TABLE 6-1 : INVENTORY OF SELECTED AGGREGATE OPERATIONS

NAME	LOCATION	AGE (a)	TYPE OF MINE	HOW MINED	STEPS IN PROCESS	WATER USES AND RATE	WATER RECYCLE	EFFLUENT TREATMENT TECHNOLOGY	FLOW RATES	OTHER POLLUTION CONTROL	TOXIC	EFFLUENT QUALITY pH	s.s. mg/L	O & G mg/L	phenolics ug/L	NH3/ NH4 mg/L
SUB-HEADING - SAND AND GRAVEL IN ONTARIO																
1. Kam Aggregates	Thunder Bay, Ont.	-	Open pit	loaders	1.crushing 2.washing 3.screening	washing aggregate, 4 364 m3/d	-	settling in 4 ponds	3324 m3/d	-	NO	7.89	28.1	3.39	6.67	-
2. Frank Kling Ltd.	Seaforth, Ont.	30	Open pit	loaders	1.crushing 2.washing 3.screening	washing aggregate	no	settling pond, discharged to unused pit	0	-	-			no discharge		
3. Lempiala Sand and Gravel	Thunder Bay, Ont.	-	Open pit	loaders	1.crushing 2.washing	washing aggregate	yes	settling pond	0	-	-			no discharge		
4. Lafarge Canada	Guelph, Ont.	-	Open pit	loaders	-	washing aggregate	yes	settling in 3 ponds	0	-	-			no discharge		
5. Franceschini Bros.	Mississauga, Ont.	-	Open pit	loaders	1.crushing 2.screening	none, dry operation	-	-	0	-	-			no discharge		
6. United Aggregate	Caledon, Ont.	-	Open pit	loaders, drag line	1.crushing 2.washing 3.seperating	washing aggregate, 0 to 76 m3/d dust suppression	yes	settling ponds	0	-	-			no discharge		
SUB-HEADING - SAND AND GRAVEL IN-USA																
1.	Boulder, Colorado	40	Open pit	hydraulic excavators	1.screening 2.washing	washing aggregate, 30 m3/min (non-freezing conditions)	yes	series of 3 ponds	0	-	-			no discharge		
SUB-HEADING - SAND AND GRAVEL IN EUROPE																
1. WBB	Heathrow, U.K.	-	Open pit	-	1.screening 2.washing	washing aggregate	yes	2 ponds, mechanical separator	0	-	-			no discharge		

SECTION 7.

BEST AVAILABLE TECHNOLOGIES

ONTARIO MINISTRY OF THE ENVIRONMENT
INDUSTRIAL MINERALS SECTOR
AGGREGATES DIVISION
BEST AVAILABLE POLLUTION CONTROL TECHNOLOGY

7. BEST AVAILABLE TECHNOLOGIES

Information on selected plant operations and practices in Ontario, the rest of Canada, U.S.A. and Europe is presented in Section 6. The full range of control and treatment technologies existing within each category was identified. This information served as the basis for the identification of Best Available Technologies for the treatment of liquid effluents arising in the three categories of the Aggregates Division.

Efforts were also made to determine the feasibility of transferring technology from one category to another where similar effluent problems might occur. The choice of technologies was not limited to those presently employed in the Aggregates Division, but included techniques employed in the Non-Metallic Minerals Division and in other industrial sectors (e.g. Metal Mining Sector), and processes proven in pilot plant operation.

An Ontario BAT plant was chosen, where possible, for each category. This plant was deemed to be the one exhibiting the best overall quality of effluent. BAT plants were similarly chosen, where possible, for the United States and the rest of the world (World BAT).

Capital and operating costs are estimated for the application of the selected BAT options at each Ontario plant in order for the plant to attain the effluent quality of the respective BAT plants in Ontario, the United States and the rest of the world. All costs are expressed in second quarter, 1992 Canadian dollars and exclude site specific costs related to such aspects as topography, site availability and unique conditions.

The costs are also estimated, where possible, for the following:

- Maximum pollution prevention
- Zero discharge

For the purpose of this document, zero discharge is defined as zero volume discharge.

Maximum pollution prevention is defined as the maximum decrease in contaminant release feasibly possible, based upon the consultant's best professional judgement. Generally, it is not possible to cost, or determine the efficiency of the practice, unless there is an exemplary existing operation after which other operations could be modelled. If there are no exemplary operations present, maximum pollution prevention generally involves either the implementation of best management practices or increased application of the best available treatment option.

The cost to produce a non toxic effluent could not be determined since the toxicity study is still in progress and the causes of toxicity are unkown at this time. All aggregate operations monitored under the MISA program produced effluent which was considered non-toxic.

7.1 QUARRIES

Liquid effluents produced by quarries in Ontario are quarry water and storm water, and the parameter to be considered for control by the best available technology is Total Suspended Solids.

The Preferred technologies for the control of suspended solids are quarry sumps and settling ponds. A quarry sump can be used alone or in combination with a settling pond.

Ontario BAT

An analysis of the reported Long Term Average (LTA) concentrations of suspended solids in the liquid effluents from the eighteen quarries monitored during the MISA program shows that a figure of 15mg/L was exceeded at only two quarries (Nelson, Bertrand and Frere). However, daily maximum concentrations in excess of 30mg/L were recorded at eleven quarries.

The seven quarries at which the daily maximum concentration was less than 30mg/L are considered to be at Ontario BAT level for control of suspended solids. Estimated costs to attain this level at the other eleven quarries are given in Table 7-1.

No data was available on the concentration and size distribution of suspended solids in the quarry effluents. No estimate could therefore be made of the size of the smallest particle to be settled out to achieve a desired concentration of suspended solids in the final effluent. The required settling times could thus not be determined directly from the data obtained.

The sizing of the settling ponds is therefore based on a nominal mean residence time of 24 hours. Selected residence times for engineered ponds are judged to be adequate for this sub-sector based on data obtained from BAT level treatment in the Non-Metallic Minerals Division. Determination of the design flow rate and the basis for estimating the capital and operating costs are described in Section 7.4 and Table 7-1.

US BAT and World BAT

The cost to attain the level of US BAT and World BAT is considered to be the same as that to achieve Ontario BAT. Contacts with sites in the United States and worldwide suggest that effluent quality at these locations is comparable to but no better than that already achieved in Ontario.

Non-Toxic Effluent

Toxicity information available indicates that none of the quarry effluents monitored are considered toxic to Rainbow Trout and Daphnia magna.

Maximum Pollution Prevention

An estimated 10% reduction in the LTA concentration of suspended solids is judged to be achievable by inclusion of a decant pond in addition to the basic Ontario BAT treatment option. The decant pond would be arranged in parallel with any settling pond to treat flow in excess of the design rate for the settling pond. The capital and operating costs are shown in Table 7-2 and cost derivation contained in Section 7.4. Specific site costs are not included, even though they may be significant and must be evaluated further by means of detailed site investigations. The proposed treatment is intended only to maximize the pollution prevention regardless of the existing effluent quality obtained at each site. In some instances the sites already meet existing guidelines with present treatment facilities.

Zero Discharge

The cost for Zero Discharge, defined as zero flow discharge, is based on a single effect evaporator to treat the quarry effluent at each site. A flash dryer is included in each evaporation circuit to produce a solid residue containing the suspended and dissolved solids in the feed to the evaporator. The basis for sizing and estimating the costs of the evaporators is described in section 7.6. Resulting emissions of carbon dioxide, carbon monoxide and trace pollutants such as benzene and toluene, from fuel combustion are not considered.

7.2 SHALE AND COMMON CLAY

Effluent from clay and shale operations consists of storm water effluent from the pit. Suspended solids is the key parameter of concern in these operations.

The selected BAT options for the control of suspended solids are quarry sumps, settling and decant ponds.

Ontario BAT

The clay and shale operation of Brampton Brick at Cheltenham was chosen as the BAT plant in Ontario.

The treatment system at this site consists of a settling pond with a capacity of 12,500m^3 located in the base of the quarry together with a decant pond, of the same capacity, located outside the quarry. The size of each pond was determined on the basis of a six hour, two year storm event.

Maximum recycle of water is practised at this facility. As a result, effluent is discharged from the decant pond to the environment only on a batch basis. Only two batches have been discharged between opening of the pit in November 1990 to March 1992. These discharges were not monitored under the MISA program although monitoring by site personnel indicated a concentration of suspended solids between 1mg/L at the start of the decant operation, increasing to 8mg/L at the end. The batch discharges were estimated as 10,000 m^3 in July 1991 and 3,000 m^3 in March 1992. These batch discharges, occurring nine months apart, equate to an equivalent mean continuous discharge of 48m^3/d over a period of 270 days.

At the four operations of Canada Brick the LTA flow rates of quarry effluent range from 306m^3/d to 2324m^3/d. These flows are considerably greater than the calculated mean continuous rate of flow at Brampton Brick. This may in part be due to the large amount of recycle undertaken at Brampton Brick.

No data were available on the concentration and size distribution of suspended solids in the effluents at the Canada Brick sites. No estimate could therefore be made of the size of the smallest particle to be settled out to achieve a desired concentration of suspended solids in the final effluent and, the settling times required could therefore not be determined. Furthermore, the concentration of clay minerals, which are known to have low rates of settling, is unknown.

The sizing of the settling and decant ponds arranged in parallel is again therefore based on nominal mean residence times of 48 and 96 hours, respectively. Flow in excess of the design rate for the settling pond is diverted into the decant pond. The residence time in the decant pond has to be sufficient to allow for settling and decantation.

The determination of the design flow rates and the basis for estimating the capital and operating costs given in Table 7-2 is described in section 7.4.

US BAT

The cost to attain US BAT level is considered to be zero at all five facilities since the quality of effluent released from US operations is no better than that which Ontario operations are currently achieving.

World BAT

The Brampton Brick operation at Cheltenham is considered to represent a World BAT. The cost to attain this level is therefore the same as that to attain Ontario BAT.

Non-Toxic Effluent

The preliminary preliminary toxicity information available indicates that none of the effluents released from the clay and shale operations were considered during MISA monitoring toxic to Rainbow Trout and Daphnia magna. No toxicity data is available for Brampton Brick at Cheltenham.

Maximum Pollution Prevention

Maximum Pollution Prevention is achieved at the same cost as that necessary to attain Ontario BAT level. The Ontario BAT operation (Brampton Brick) currently employs Pollution Prevention Practices and Best Management Practices.

Zero Discharge

The cost for Zero Discharge flow is based on a single effect evaporator to treat the quarry effluent at each site. A flash dryer is included in each evaporation circuit to produce a solid residue containing the suspended and dissolved solids in the feed to the evaporator. The basis for sizing and estimating the costs of the evaporators is described in Section 7.6.

7.3 SAND AND GRAVEL

Sand and gravel operations in Ontario utilize open pit mining followed by crushing and wet screening to remove clay and silt. The water used in these operations is recycled. The only sand and gravel operation in Ontario which discharges effluent off-site, and therefore was monitored under the MISA program, is Kam Aggregates.

The cost of a settling pond to achieve full recycle of water at this facility is given in Table 7-3 and the basis for estimating the capital and operating costs of this settling pond is described in section 7.4. The mean residence time in the pond is 24 hours at the design flow rate. The design flow rate is calculated as the LTA flow rate multiplied by VF1 (the daily variability factor). This settling pond satisfies all of the requirements for Ontario BAT, US BAT, World BAT, Maximum Pollution Prevention and Zero Discharge.

7.4 CONTROL OF SUSPENDED SOLIDS

7.4.1 Quarry Sumps

The three main purposes of sumps are as follows:

- to serve as the catchbasin for rainfall run-off
- to act as a primary settling basin
- to provide a reservoir for a dewatering pump

The size and location of the sump are dependent on a number of factors which include the following:

- available quarry area
- peak rainfall run-off to which the pit might be subjected
- availability of additional storage (e.g. a low bench) that can be allowed to fill during periods of peak run-off
- anticipated pumping capacity
- access to the sump for cleaning

At sites which have more than one quarry or pit, the sumps can be used in series with effluent being discharged only from the last sump.

Location of the pump sump is one of the most critical aspects affecting the quality of the discharged effluent. The pump suction line should be located in a quiescent area of the sump in order to take full advantage of settling in the sump and to avoid the introduction of material that would produce undesirable levels of suspended solids.

7.4.2 Settling Ponds

Design

The mechanism of separation in settling ponds, in the absence of any chemical pretreatment (e.g. flocculation) of the feed, is "free" or "ideal" settling in which solid particles settle independently of one another. This settling regime is governed by Stoke's Law which expresses the settling velocity of particles, assumed to be spherical, in terms of their physical properties (diameter and specific gravity) and the kinematic viscosity of water.

The design of a settling pond is dependent upon a number of factors which include the following:

- expected range of concentration of suspended solids in the influent
- size distribution of suspended solids in the influent
- expected range of water temperature
- expected range of flow rate of the influent
- maximum allowable concentration of suspended solids in the effluent.

The first step in the design procedure is to determine the diameter of the smallest particle to be settled out in order to meet the effluent limit. The size of this particle is calculated from the flow rate of influent and the size distribution of suspended solids in the influent.

The next step is to calculate the settling velocity of this particle using Stoke's Law.

$$Vs = gD^2 (Ss-1)/18u$$

where
Vs = settling velocity (cm/sec)
g = gravitational acceleration (981 cm/sec^2)
u = kinematic viscosity of water (cm^2/sec)
Ss = specific gravity of particle
D = diameter of particle (cm)

The area in plan, A, of the settling pond is then calculated from the following equation for the removal ratio R.

$$R = Vs/Vo = (C_1 - C_2)/C_1$$

where Vs = settling velocity of smallest particle (m/h)

Vo	=	overflow velocity (m/h) = Q/A
Q	=	flow rate of influent (m^3/h)
C_1	=	concentration of suspended solids in the influent (mg/L)
C_2	=	concentration of suspended solids in the effluent (mg/L)

This equation is based on the assumption that all particles with a settling velocity greater than the overflow velocity will settle out.

Dimensions of the pond are chosen to ensure that scouring does not occur and that turbulence and short circuiting are minimized.

Scouring occurs when the horizontal velocity of the fluid is high enough to pick up settled particles from the bottom of the pond and sweep them away. The cross-sectional area of the pond should be large enough to ensure that the horizontal velocity does not exceed the scour velocity.

Turbulence caused by "in-pond" factors can be controlled by inlet and outlet conditions and by sizing the pond correctly.

Various inlet configurations are used within this and related industries to minimize turbulence through the partition of flows. A well designed system encountered by the study team was the UL200 system currently in use at the Petschmorgen Works of Fuchs' Sche Tongruben in Germany. With this system, the settling pond is preceded by a small "stilling" basin into which the feed pipe discharges. The overflow from this basin flows via three pipes into a 400 mm diameter distributor pipe which extends across the width of the settling pond. The incoming fluid is discharged from this distributor through holes in a direction opposite to its ultimate direction of flow toward the outlet of the pond. A section through this feed distributor is shown in Figure 7-1. Special design considerations and/or modifications may be required to address winter freezing conditions, especially where intermittent flows are expected.

The preferred outlet assembly consists of a pipe which extends across the width of the pond. Effluent flows via a V-notch weir into cutaways at the top of the pipe. The V-notch weir extends along the full length of the outlet pipe and on both sides of the cutaway.

Turbulence can also be created by external factors such as wind. Wind breaks may be necessary to reduce the effects of such turbulence in extreme cases. Long, narrow, rectangular ponds are generally affected less by turbulence and short circuiting. As a general rule the ratio of the length to the width should not be less than 5:1.

Capital Costs

The installed cost of a settling pond varies greatly depending upon a number of factors such as:

- extent of excavation required
- need for blasting
- surrounding topography
- extent of diversion of storm water run-off around the pond
- access to the pond for cleaning

For the purposes of this study, the design of the settling ponds is based on the following assumptions:

- a relatively flat site is available at no cost
- soil can be excavated without the need for any blasting
- excavated soil is suitable for the building of dykes around the four sides of the pond
- borrow material is needed for the construction of the dykes
- sides of the excavation and the dykes have a slope of 2:1
- crest width of the dykes is 5 metres
- ratio of the length to the width at the top of the settling pond is 5:1
- influent is evenly distributed across the full width of the pond
- combined feed is available either at the discharge side of a feed pump or at an elevation sufficient for gravity flow into the pond
- pond effluent is collected evenly across the full width of the pond
- discharge flows by gravity to its point of release to the environment

The capital cost of each engineered settling pond is based on the following:

- cost of earthworks is $10.00/m^3$ of excavated soil. This figure includes the cost of site preparation, excavation, compaction of dykes and surface grading.
- settling pond is unlined
- cost of the feed distribution and overflow collection systems is $1,500 /m of pond width
- an allowance is made for a feed pipe laid on surface over a distance of 500 metres. The unit installed cost of this piping varies from $50.00/m for 150mm pipe to $110.00/m for 450mm pipe.

- an allowance is made for a discharge pipe laid on surface over a distance of 500 metres. The unit installed cost of this piping varies from $80.00/m for 225mm pipe to $200.00/m for 800mm pipe
- an allowance of 10% is provided to cover the costs of engineering
- a 15% contingency is included
- cost of disposal of dredgings is excluded

The design and capital cost of each decant or batch settling pond includes all of the items listed above with the following exceptions:

- decant pond is square in cross-section
- allowance of $1,500/m of pond width for the feed distribution and overflow collection systems is excluded

The above assumptions are based on typical site conditions but it is recognized that each operation in Ontario has certain unique features which cannot be addressed without detailed examination of the site. The estimated costs developed in this study do not include site specific costs related to topography, site availability and other unique conditions.

The design flow rate, into the settling pond, FSP, is determined from the following formula incorporating MISA monitoring values and definitions:

$$FSP = LTAF \times VF4$$

where LTAF = long term average flow rate (m^3/d)
VF4 = monthly 4-day variability factor
(calculated from 95th Percentile of data [P95]/Long term average)

The design flow rate into the decant pond, FDP, is determined from the following formula:

$$FDP = LTAF \times (VF1 - VF4)$$

where VF1 = daily variability factor
(calculated from 99th Percentile of data [P99]/Long term average)

A VF1 of 6.547 was used in estimating the size of the decant ponds at the R.E. Law, Ridgemount and Boyce quarries. This value is the average of VF1 figures for the other 15 quarries.

The settling and decant ponds are arranged in parallel and the decant pond is operated on a batch basis.

Values of LTAF, VF1 and VF4 are listed in Table 7-4.

Operating Costs

Labour and machinery are required for maintenance of a settling pond to avoid adverse effects on its operation. Typical items on the maintenance list are as follows:

- cleaning of the pond on a regular schedule (annual or less frequent basis) to ensure peak efficiency
- removal of settled solids to a disposal area such that they do not wash back into the pond or cause off-site sedimentation problems
- maintenance of slopes or banks
- periodic checking and repair of pipes, weirs and structures
- maintenance of storm water diversion ditches

The annual cost of labour and machinery is estimated to be $20,000 for a 2,000m³ pond. This figure is estimated to increase to $30,000 for a pond with a capacity of 20,000m³. No allowance is made in the operating costs for the addition of treatment aids such as flocculants and coagulants.

7.4.3 Overseas Developments

Unlike Ontario, where suspended solids removal in the Aggregates Division is solely by physical settling (ponds or sumps), in the United Kingdom the use of technologies employing flocculation is in evidence in the treatment of effluents contaminated with clay. As an example, future effluent treatment plants at the works of English China Clay in Cornwall the first major plant is due to come on stream at St. Austell in May 1992 will incorporate conventional thickeners.

At a sand and gravel pit close to Heathrow Airport in England a dynamic separator is in operation. The clay content of this quarry deposit, like most others in the U.K., is about 5%. Prior to the installation of a "Silt-Pac" separator, two settling ponds in series were used to clarify the dirty water for recycle to the washing and screening circuit. The settling ponds proved ineffective and a high circulating load of clay resulted.

The Silt-Pac unit comprises two components - a concentrator and a thickener. Flocculant is added to the feed slurry which is introduced tangentially into the cylindrical concentrator. A gentle rotation is set up about the vertical axis. The flow first spirals gradually down the perimeter allowing enough time for solids to settle by gravity. The settling process is aided by the drag forces of the boundary layer at the wall and bottom surfaces of the cylinder.

The underflow from the concentrator is fed to the thickener. Further gravity settling occurs in this unit to produce a final sludge for disposal in discussed parts of the quarry.

This Silt-Pac unit was designed to treat 270 m³/h with an installed cost of approximately $290,000. The total dosage of flocculant varies from 15 to 25 mg/L of feed.

7.5 OTHER PARAMETERS

7.5.1 Ammonia/Ammonium

Ammonia and the ammonium ion are generally found in the effluents from quarries where ANFO (ammonium nitrate/fuel oil) is used as the blasting agent. The use of strict handling procedures for ANFO and the immediate clean up of spills are prerequisites for the control of ammonia in liquid effluents.

In agricultural areas there is also however, a potential for introduction of ammonia/ammonium into surface waters from other sources (e.g. fertilizers).

There are no operations in the Aggregates Division or Non-Metallic Minerals Division where effluent is treated to control ammonia/ammonium alone. Available technologies from other industrial sectors are not applicable to effluents in this division. Thus there is no BAT level operation nor preferred technologies. Reduction of ammonia levels is therefore best attained by a combination of Pollution Prevention Practices and coincidental reduction by natural degradation in settling ponds designed for control of suspended solids.

7.5.2 Phenolics

Reagents containing phenol and its derivatives are not used in the Aggregates Division. The most likely source of phenolic contamination of liquid effluents is the decay of organic matter. Waste water contamination by phenolics appears to be limited to a few effluents monitored in the Aggregates Division.

There are no operations in the Aggregates Division or the Non-Metallic Minerals Division where effluents are treated to control phenolics specifically, nor do any appear in the survey of operations outside Ontario. Thus there is no BAT option selected. Available technologies do not appear to be applicable to Aggregates Division effluents and therefore phenolics content at the levels present are judged to be not treatable. Maximum reduction would be attained by natural degradation during coincidental treatment for suspended solids, and the application of Pollution Prevention Practices.

7.6 ZERO DISCHARGE COSTS

The design criteria and capital and operating costs to evaporate 1,000 and 10,000m^3/day of liquid effluent to dryness are presented below. The costs are based on the use of a natural gas fired evaporator following by flash drying to produce a dry solid residue for disposal.

Design Criteria	Units	Case A	Case B
No. of operating days per year	#	365	365
Total water vaporized	m^3/d	1,000	10,000
Water vaporized in evaporator	m^3/d	950	9,500
Waste vaporized in flash dryer	m^3/d	50	500
Efficiency of vaporization process	%	75	75
Capital Cost of Installation	$	2,200,000	8,800,000
Annual Operating Cost	$	4,500,000	40,500,000

The capital costs vary with design capacity to the power of 0.6 and are based on the use of carbon steel as the material of construction for the evaporator and flash dryer. No allowance is made for the cost of disposal of the solid residue and feed pretreatment (e.g. pH adjustment and deaeration), if required.

Fuelling by natural gas accounts for over 90% of the total operating cost, based on a unit cost of natural gas estimated at $129/million m^3.

The design flow rate of the feed to the evaporators is calculated as the LTA flow rate multiplied by the monthly four day variability factor, VF4. VF4 is defined in Section 7.4.

TABLE 7-1 AGGREGATES DIVISION - COSTS OF BAT OPTIONS

CATEGORY: QUARRIES

NAME OF QUARRY	COST TO ATTAIN ONTARIO BAT	COST TO ATTAIN US BAT	COST TO ATTAIN WORLD BAT	COST FOR MAXIMUM POLLUTION PREVENTION	COST FOR ZERO DISCHARGE
R.W.Tomlinson	Settling pond $101,000 $19,000 [78 to 30]	Settling pond $101,000 $19,000 [78 to 30]	Settling pond $101,000 $19,000 [78 to 30]	Settling pond + decand pond $208,000 $43,000 [30 to 27]	Evaporator $2,900,000 $8,900,000
R.E.Law	Zero cost {17}	Zero cost {17}	Zero cost {17}	Decant pond $834,000 $43,000 [17 to 15.3]	Evaporator $10,900,000 $56,500,000
Lafarge N+S	Settling pond $167,000 $23,000 [39 to 30]	Settling pond $167,000 $23,000 [39 to 30]	Settling pond $167,000 $23,000 [39 to 30]	Settling pond + decant pond $375,000 $53,000 [30 to 27]	Evaporator $5,800,000 $20,800,000
Cornwall	Settling pond $149,000 $22,000 [35 to 30]	Settling pond $149,000 $22,000 [35 to 30]	Settling pond $149,000 $22,000 [35 to 30]	Settling pond + decant pond $386,000 $52,000 [30 to 27]	Evaporator $5,000,000 $18,400,000
Dufferin	Zero cost {22}	Zero cost {22}	Zero cost {22}	Decant pond $181,000 $29,000 [22 to 19.8]	Evaporator $9,700,000 $47,000,000
Nelson	Settling pond $373,000 $31,000 [2811 to 30]	Settling pond $373,000 $31,000 [2811 to 30]	Settling pond $373,000 $31,000 [2811 to 30]	Settling pond + decant pond $840,000 $68,000 [30 to 27]	Evaporator $15,300,000 $98,800,000

Capital costs appear above annual operating costs.

Figures in { } are daily maximum concentrations (mg/L) of suspended solids reported during the MISA program.

Figures in [ ] are daily maximum concentrations (mg/L) of suspended solids in monitored effluent and the level to be attained by BAT application.

Site specific costs are not included (See Section 7.4)

TABLE 7-1 AGGREGATES DIVISION – COSTS OF BAT OPTIONS (CONTINUED)

CATEGORY: QUARRIES

NAME OF QUARRY	COST TO ATTAIN ONTARIO BAT	COST TO ATTAIN US BAT	COST TO ATTAIN WORLD BAT	COST FOR MAXIMUM POLLUTION PREVENTION	COST FOR ZERO DISCHARGE
Bertrand and Frere	Settling pond $151,000 $23,000 [445 to 30]	Settling pond $151,000 $23,000 [445 to 30]	Settling pond $151,000 $23,000 [445 to 30]	Settling pond + decant pond $353,000 $52,000 [30 to 27]	Evaporator $5,000,000 $18,700,000
Carden	Settling pond $64,000 $16,000 [89 to 30]	Settling pond $64,000 $16,000 [88 to 30]	Settling pond $64,000 $16,000 [89 to 30]	Settling pond + decant pond $118,000 $35,000 [30 to 27]	Evaporator $1,500,000 $2,400,000
Ridgemount	Settling pond $165,000 $23,000 [44 to 30]	Settling pond $165,000 $23,000 [44 to 30]	Settling pond $165,000 $23,000 [44 to 30]	Settling pond + decant pond $532,000 $58,000 [30 to 27]	Evaporator $5,700,000 $20,300,000
Amherst	Settling pond $120,000 $21,000 [55 to 30]	Settling pond $120,000 $21,000 [55 to 30]	Settling pond $120,000 $21,000 [55 to 30]	Settling pond + decant pond $214,000 $44,000 [30 to 27]	Evaporator $3,700,000 $10,100,000
Allan G. Cook	Settling pond $74,000 $17,000 [32 to 30]	Settling pond $74,000 $17,000 [32 to 30]	Settling pond $74,000 $17,000 [32 to 30]	Settling pond + decant pond $152,000 $38,000 [30 to 27]	Evaporator $1,800,000 $3,300,000
Eglinburg	Zero cost {13}	Zero cost {13}	Zero cost {13}	Decant pond $228,000 $30,000 [13 to 11]	Evaporator $5,200,000 $17,600,000

Capital costs appear above annual operating costs.

Figures in { } are daily maximum concentrations (mg/L) of suspended solids reported during the MISA program.

Figures in [ ] are daily maximum concentrations (mg/L) of suspended solids in monitored effluent and the level to be attained by BAT applications.

Site specific costs are not included (see Section 7.4)

TABLE 7-1 AGGREGATES DIVISION - COSTS OF BAT OPTIONS (CONTINUED)

CATEGORY: QUARRIES

NAME OF QUARRY	COST TO ATTAIN ONTARIO BAT	COST TO ATTAIN US BAT	COST TO ATTAIN WORLD BAT	COST FOR MAXIMUM POLLUTION PREVENTION	COST FOR ZERO DISCHARGE
Flamboro	Settling pond $181,000 $24,000 [88 to 30]	Settling pond $181,000 $24,000 [88 to 30]	Settling pond $181,000 $24,000 [88 to 30]	Settling pond + decant pond $430,000 $55,000 [30 to 27]	Evaporator $8,400,000 $24,500,000
Richler	Zero cost {11}	Zero cost {11}	Zero cost {11}	Decant pond $93,000 $23,000 [11 to 10]	Evaporator $990,000 $1,300,000
Boyce	Zero cost {23}	Zero cost {23}	Zero cost {23}	Decant pond $284,000 $33,000 [23 to 21]	Evaporator $4,200,000 $12,400,000
Macleod	Zero cost {24}	Zero cost {24}	Zero cost {24}	Decant pond $93,000 $23,000 [24 to 22]	Evaporator $2,500,000 $5,700,000
Uhtoff	Settling pond $233,000 $27,000 [190 to 30]	Settling pond $233,000 $27,000 [190 to 30]	Settling pond $233,000 $27,000 [190 to 30]	Settling pond + decant pond $315,000 $48,000 [30 to 27]	Evaporator $8,800,000 $40,700,000
Milton Limestone	Zero cost {22}	Zero cost {22}	Zero cost {22}	Decant pond $84,000 $22,000 [22 to 20]	Evaporator $2,300,000 $4,700,000

Capital costs appear above annual operating costs.

Figures in { } are daily maximum concentrations (mg/L) of suspended solids reported during the MISA program.

Figures in [ ] are daily maximum concentrations (mg/L) of suspended solids in monitored effluent and the level to be attained by BAT applications.

Site specific costs are not included (see Section 7.4)

TABLE 7-2 AGGREGATES DIVISION - COSTS OF BAT OPTIONS

CATEGORY: CLAY AND SHALE

NAME OF PLANT	COST TO ATTAIN ONTARIO BAT	COST TO ATTAIN US BAT	COST TO ATTAIN WORLD BAT	COST FOR MAXIMUM POLLUTION PREVENTION	COST FOR ZERO DISCHARGE
Brampton Brick, Cheltenham	Zero cost {<15}	Zero cost. Inferior effluent quality at known US sister plants.	Zero cost. Believed to be World BAT	Zero cost	Evaporator $490,000 $410,000
Canada Brick, Burlington	Settling pond + decant pond $141,000 $39,000 [283 to 15]	Settling pond + decant pond $141,000 $39,000 [283 to 15]	Settling pond + decant pond $141,000 $39,000 [283 to 15]	Settling pond + decand pond $141,000 $39,000 [283 to 15]	Evaporator $1,550,000 $2,600,000
Canada Brick, Cooksville	Settling pond + decant pond $582,000 $63,000 [128 to 15]	Settling pond + decant pond $582,000 $63,000 [128 to 15]	Settling pond + decant pond $582,000 $63,000 [128 to 15]	Settling pond + decant pond $582,000 $63,000 [128 to 15]	Evaporator $6,000,000 $22,000,000
Canada Brick, Gloucester	Settling pond + decant pond $298,000 $51,000 [103 to 15]	Settling pond + decant pond $298,000 $51,000 [103 to 15]	Settling pond + decant pond $298,000 $51,000 [103 to 15]	Settling pond + decant pond $298,000 $51,000 [103 to 15]	Evaporator $4,800,000 $15,500,000
Canada Brick, Streetsville	Settling pond + decant pond $208,000 $45,000 [48 to 15]	Settling pond + decant pond $208,000 $45,000 [48 to 15]	Settling pond + decant pond $208,000 $45,000 [48 to 15]	Settling pond + decant pond $208,000 $45,000 [48 to 15]	Evaporator $2,400,000 $5,000,000

(1) Expected LTA concentrations will be lower than those achieved at sister US plants.

Capital costs appear above annual operating costs.

Figures in { } are the LTA concentrationa (mg/L) of suspended solids reported during the MISA program.

Figures in [ ] are the LTA concentrations (mg/L) of suspended solids in the monitored effluent and the level to be attained by BAT application.

Site specific costs are not included (see Section 7.4).

TABLE 7-3 AGGREGATES DIVISION - COSTS OF BAT OPTIONS

CATEGORY: SAND AND GRAVEL

NAME OF PLANT	COST TO ATTAIN ONTARIO BAT	COST TO ATTAIN US BAT	COST TO ATTAIN WORLD BAT	COST FOR MAXIMUM POLLUTION PREVENTION	COST FOR ZERO DISCHARGE
Kam Aggregates	Settling pond (1) $280,000 $28,000	Settling pond (1) $280,000 $28,000	Settling pond (1) $280,000 $28,000	Settling pond (1) $280,000 $28,000	Settling pond (1) $280,000 $28,000

(1) Settling pond for total recycle.

Capital costs appear above annual operating costs.

Site specific costs are not included (see Section 7.4)

CATEGORY: QUARRIES

TABLE 7-4 AGGREGATES DIVISION - EFFLUENT FLOW RATE DATA

NAME OF QUARRY	LTAF	VFI	VF4
R.W. Tomlinson	663	6.609	2.326
R.E. Law	14088	1.022	1.007
Lafarge N+S	2025	7.170	2.455
Cornwall	1835	7.709	2.109
Dufferin	7572	2.533	1.542
Nelson	13831	4.283	1.810
Bertrand & Frere	1152	11.317	3.428
Carden	275	4.382	1.647
Ridgemount	4379	1.048	1.103
Amherst	1539	2.940	1.513
Allan G.Cook	254	8.682	2.811
Eglinburg	1079	14.045	3.864
Flamboro	1922	9.745	3.064
Richler	565	8.012	2.191
Boyce	2878	1.001	1.001
Macleod	587	5.828	2.149
Uhtoff	8792	1.330	1.142
Milton Limestone	493	5.627	2.105

LTAF = Long term average flow rate (m^3/d)
VFI = Daily variability factor
VF4 = Monthly four day variability factor

TABLE 7-4 AGGREGATES DIVISION - EFFLUENT FLOW RATE DATA (CONTINUEL)

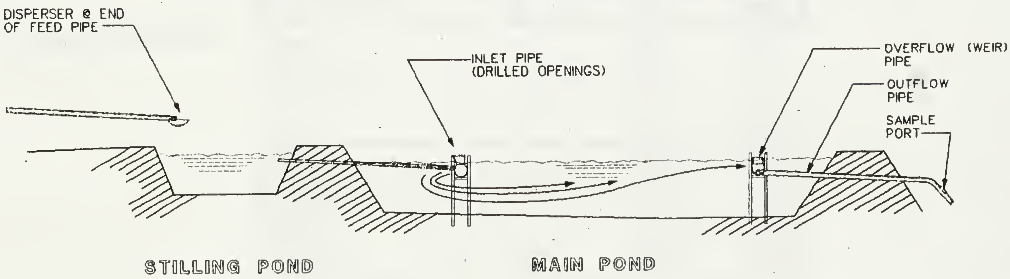
CATEGORY: CLAY AND SHALE

NAME OF PLANT	LTAF	VFI	VF4
Brampton Brick, Cheltenham	no data	no data	no data
Canada Brick, Burlington	308	4.209	1.793
Canada Brick, Cooksville	1455	13.094	3.595
Canada Brick, Gloucester	2324	2.591	1.562
Canada Brick, Streetsville	538	5.480	2.072

CATEGORY: SAND AND GRAVEL

NAME OF PLANT	LTAF	VFI	VF4
Kam Aggregates	3324	4.363	1.827

LTAF = Long term average flow rate (m^3/d)
VFI = Daily variability factor
VF4 = Monthly four day variability factor



KILBORN

GENERAL ARRANGEMENT OF SETTLING POND

DRAWING NUMBER FIGURE 7-1

SECTION 8.
POLLUTION PREVENTION PRACTICES

ONTARIO MINISTRY OF THE ENVIRONMENT
INDUSTRIAL MINERALS SECTOR
AGGREGATES DIVISION
BEST AVAILABLE POLLUTION CONTROL TECHNOLOGY

8. POLLUTION PREVENTION PRACTICES

Pollution Prevention Practices (PPP) are those activities, infrastructure, and/or facilities, which are used in order to minimize the potential for, or impact of, an operation on surrounding surface waters. The PPP's which apply to the Aggregates Division may be subdivided according to whether the practice is specific to a certain aggregate category, or whether it may be applied within the entire sector.

PPP's differ from BAT's in that they tend to control pollutants at source and provide control of upsets, rather than provide treatment of ensuing effluent. The degree of pollution prevention achieved through use of PPP therefore tends to be more variable and difficult to quantify. PPP can also be viewed in some instances, such as operator training, as a means of optimizing BAT performance.

For these reasons, PPP's are not regarded as being equivalent to BAT's. In certain cases, and particularly for the Aggregates Sector where good housekeeping plays such an important role in pollution prevention, the implementation of a PPP program may successfully fulfil the role of BAT.

8.1 BEST MANAGEMENT PRACTICES (BMP)

This section addresses those management practices which, although they possibly are employed within only one Aggregate Division category (or outside of the sector entirely), may be applied to a variety of Aggregate Division operations. Best Management Practices such as; drainage management, spill management, management of materials storage, and rehabilitation, form a major part of Pollution Prevention Practices.

8.1.1 Drainage Management

The management practice which may have the greatest positive impact on effluent quality is drainage control. Drainage control may be categorized as either:

i) preventative in nature, designed to reduce the amount of water inputs to the system, and hence the amount of effluent requiring treatment, or
ii) controls designed to minimize the quantity of contaminant entering into the effluent stream.

The two categories are treated separately but are not necessarily exclusive.

Preventative Measures

Within the Aggregates Sector, various effluent types are represented. The largest individual source of water requiring discharge generally arises from precipitation (direct or as surface run-off) or ground water. The proper management or segregation of these sources can significantly reduce the amount of contaminated water produced by the operation, and hence, the amount requiring treatment. Installation of measuring devices, control devices and where applicable, level sensors will aid the collection of water flow data which can be used to develop a management strategy.

Surface Water:

The principal means of controlling the amount of surface water input to the operation is to divert the product of catchment areas away from the site where practical, or to design and implement a stormwater management plan.

While the main benefit of these practices is to reduce the surface water inputs requiring treatment (thereby reducing design requirements and operating costs of the system), there are other positive aspects to this practice. By minimizing the surface water inputs to the treatment system, it reduces the chance of treatment system overload during peak inputs from storms or spring run-off.

The diversion of surface waters away from the site also reduces the opportunity for foreign contaminants to enter onto the site. It was noted during visits to some sites in Ontario, that off-site water inputs sometimes appeared to carry elevated levels of suspended solids and may carry other contaminants of a higher concentration than those generated by the operation itself. Surface waters may be contaminated by run-off from public roads, or agricultural lands, for example. Run-off from public roads can introduce contaminants such as oil and grease, while run-off from agricultural lands could introduce suspended solids, nitrate, phosphorus, pesticides and other contaminants into the effluent of the Aggregate operation.

Groundwater:

Groundwater management at surface operations can also reduce the volume of effluent requiring treatment. Discussions with personnel involved directly in Aggregate Division operations, suggested that groundwater inputs from 4000 to 7500 m^3 per day along a quarry face are not unusual. This is especially true of limestone quarries, where springs along the quarry face may have peak discharges during snow melt conditions, or in association with storm events.

In order to reduce the contamination of ground water, flows should be intercepted and diverted away from workings to the extent possible. This can best be accomplished by excavating ditches close to the non-working faces of pits or quarries. Ditches along working faces are impractical as they would interfere with operations. In addition, a ditch located along the face at quarry/pit sink, would serve to collect surface waters, and would therefore not allow the proper segregation of uncontaminated ground water.

Minimize Level of Contamination

The most common method of limiting contamination utilized within the Aggregates Division is the strategic placement of ditches throughout the site. Control of erosion and surface exposures of stockpiles is also critical to the restriction of contaminant loading at source.

If properly placed, ditches should collect virtually all surface run-off and divert it away from roads, storage piles and other facilities. By collecting the run-off immediately, the potential for contamination is minimized both directly and indirectly. Direct contamination may occur whenever there is surface water present. Indirect contamination may occur as vehicles pass through standing water and then become covered in mud and other materials which must be removed by washing.

8.1.2 Spill Management

Spills of materials associated with site operations (such as raw materials, reagents, fuel) may occur even under the best of procedures, and may result in the contamination of site water. Thus, the BMP is to minimize the potential for spillage, and to control any impact if a spill occurs.

The best procedure for control of all spills, no matter what the substance or how small the spill, is to provide proper spill containment facilities as part of the plant site design and to practice, specific spill clean up strategies. Although a spill of raw materials may not pose a real danger, the uncontained material spills may contaminate surface run-off. Of specific concern is the clean up and disposal of any spilled fuels or blasting agents. The explosive most commonly used in quarrying operations is a mixture of ammonium nitrate and fuel oil (ANFO), containing approximately 95% ammonium nitrate. This material dissolves rapidly in water, and hence any ANFO spills (or spills of ammonium nitrate) should be cleaned up immediately. ANFO spills are commonly regarded as the main cause of elevated levels of ammonia/ammonium in quarry or minewater.

In the case of most materials, clean up will entail only the removal of materials by shovel, or other means. With petroleum products as well as hazardous materials, however, special handling procedures

are required. Plant personnel associated with these materials should be trained in their proper handling, clean up and disposal procedures. Clean up materials such as adsorbants should be present at all times.

In order to minimize the potential impact of spills, spill containment structures should be placed around storage locations. Commonly ditches or berms are used to contain any spills or leakages until they can be managed according to the applicable regulations.

8.1.3 Storage Management

Storage practices in addition to those already mentioned under spill management, may help reduce the amount of suspended solids released to surrounding surface waters by aggregate operations. Run-off from raw material storage piles may be a source of this sediment. Although it is not necessarily practical for all materials to be covered, those materials that are easily washed away, should be covered, or their drainage should be contained and segregated from other site run-off.

Another way to limit contaminant release from storage piles, is the development of a wind screen to block the prevailing wind direction. By limiting the amount of dust released into the atmosphere, indirectly the amount of contaminant in the surface water is reduced. These screens may be either developed specifically for wind control, such as a screen of trees; or the storage piles may be located so as to take advantage of the conditions downwind of a large building or other structure.

8.1.4 Rehabilitation

Progressive rehabilitation may significantly reduce the quantity of fine material released into surface waters. Grading of slopes and revegetation decreases the amount of sediment picked up by surface run-off, and also sharply decreases the amount of material that can be entrained by winds, to be deposited and later re-entrained, by run-off.

8.2 WATER REUSE / CONSERVATION

Recycle is practised to some extent at most aggregate operations. At those operations with washing facilities (some quarries, and sand and gravel operations), the water is often drawn from settling ponds or other on-site sources. Depending upon the availability of this source (related principally to the time of year), supplemental water may be drawn from off-site sources as required.

The other major re-use of water possible on-site, is for dust control. This is applicable to all aggregate operations, but especially to clay and shale operations. Effluent may be sprayed on stockpiles, working areas and roads to control dust during dry weather.

Application of these practises where practical, could aid in decreasing the amount of effluent requiring treatment and discharge off-site.

8.3 PROCESS CHANGE

Due to the nature of processing within the Aggregates Division (generally crushing, screening and occasionally washing) implementation of process changes other than those addressed as Best Management Practices or Water Reuse / Conservation, is generally not possible, and would be unlikely to have an impact on water quality.

8.4 CATEGORY SPECIFIC BEST MANAGEMENT PRACTICES

8.4.1 Quarries

In order to limit the loading of surface waters with solids, all waters used in the washing of raw materials should be directed to treatment ponds to remove suspended solids and allow for recirculation of water.

All fines associated with the crushing of stone should be stored in a protected area, and covered as soon as practical. The fine texture makes these materials readily entrained by either the wind or surface run-off.

Any water used for washing vehicles, or dust control, should be drawn from existing water sources on-site (for example sumps or settling ponds), where possible to reduce the quantity drawn from surrounding natural watercourses.

8.4.2 Shale and Common Clay

Due to the nature of crushed shale and clay when wet, if practical the driveway leading to the main road should be paved. In this way, any clay attached to the tires of the vehicle will drop off on-site. In order to facilitate the removal of this material from the driveway during precipitation events or during washing, the road should be sloped slightly to one side, and a collection ditch should be placed to return this run-off to the effluent treatment area.

Any dry shale or clay should either be stored under cover, or care should be taken to minimize dust production by spraying with effluent to maintain a damp surface. If stored outdoors, run-off from the storage piles should be collected and treated.

Any water used for dust suppression within the pit, on storage piles or roads, should be drawn from the settling pond or sump.

8.4.3 Sand and Gravel

The Best Management Practices associated specifically with sand and gravel operations is the practice of recirculating all wash water, and zero discharge of effluents off-site. It is expected that this practice would be practical for all Ontario operations.

SECTION 9.
ZERO DISCHARGE

ONTARIO MINISTRY OF THE ENVIRONMENT
INDUSTRIAL MINERALS SECTOR
AGGREGATES DIVISION
BEST AVAILABLE POLLUTION CONTROL TECHNOLOGY

9. ZERO DISCHARGE

9.1 ZERO EFFLUENT DISCHARGE

Zero volume discharge is regulated and readily attainable, for operations in dry and/or arid climates, which are characterized by net surface evaporation. These practices would apply for example, at operations within the southern and western regions of the United States. In Ontario, annual precipitation exceeds maximum annual open water evaporation by 200 to 500 mm annually. As a result, a net surplus of water is collected at any given site via processes of surface run-off, precipitation and groundwater inputs. Natural evaporation processes are not capable of eliminating the annual water accumulation, and as a result, water volume reduction can be achieved only through treatment systems or use for process water where applicable.

Where practical, on-site water requirements may be drawn from this net water accumulation, and may decrease or eliminate the amount of water which would otherwise be discharged off-site as effluent. Generally the water accumulated at the site via storm water run-off, open pit or quarry operations is much greater than potential water loss associated with on-site reuse or recycle.

Of the three producing aggregate categories considered within this document, the sand and gravel category is the most amenable to zero discharge of effluent. Within Ontario, all sand and gravel operations contacted (except one) are currently non-dischargers. Zero volume discharge at these operations is attributable to the high porosity of the aggregates which allows surplus waters to seep into the ground. The use of several ponds on-site should allow the reuse of all waters within washing processes, thereby eliminating the requirement to discharge effluent off-site.

The clay and shale category may also be amenable to near zero volume discharge, depending to a large extent on specific site conditions. A recently built clay and shale pit at Cheltenham is able to reuse virtually all of its surface water on-site for washing down paved roads and for dust control on the stockpiles and working areas. Unfortunately, the period of peak water surplus (generally spring run-off), is not the period when the water could be best used for dust control on-site. Based on the limited amount of data available at this time, it appears that this operation may be able to retain or reuse all

surface run-off except during peak storm events or prolonged wet periods. It is anticipated that the discharge of effluent off-site may be required once or twice per year.

Excluding the limited number of quarries which are located above the water table, operations within the quarry category would not be able to attain zero volume discharge using conventional means. The amount of groundwater inputs along the quarry face, as well as precipitation inputs over the generally large area taken up by the quarry, would not allow zero discharge except with the implementation of large-scale evaporators. Evaporators are not currently in use at any aggregate operation worldwide. The potential economic cost to the operation, and the cost to the environment of utilizing the required amount of energy for evaporation of large quantities of water, make this an impractical solution. Quarry operations may however, reuse some of the surplus water on-site in washing operations (where applicable) and for dust control. Both practices would decrease the amount of direct effluent discharge required.

9.2 VIRTUAL ELIMINATION OF TOXICS

Preliminary data from the MISA study indicated that none of the Aggregate producers in Ontario monitored, released an effluent which was considered toxic to either Daphnia magna or Rainbow Trout. The toxicity is based upon an LC50 test on these organism's for either 48 hours or 96 hours. Based on this preliminary data it appears that a non-toxic effluent is likely to be achieved by operations within the Aggregates Division. At the time of writing, there is insufficient information available to further address toxicity within this Division.

SECTION 10.

SUMMARY AND CONCLUSIONS

ONTARIO MINISTRY OF THE ENVIRONMENT
INDUSTRIAL MINERALS SECTOR
AGGREGATES DIVISION
BEST AVAILABLE POLLUTION CONTROL TECHNOLOGY

10. SUMMARY AND CONCLUSIONS

10.1 FULFILMENT OF THE STUDY OBJECTIVES

The principle objectives defined in the terms of reference are the following:

(1) to develop an inventory of water pollution control technologies presently used in the recovery and processing of aggregates worldwide, focusing on design, operating conditions, performance, and capital and operating costs.

(2) to develop an inventory of generic waste water pollution control technologies used in other industrial sectors, which could be applied to the aggregates sector

(3) to determine where possible, up to five technology trains which can be applied to different plant types to achieve BAT option goals, and

(4) to estimate performance and capital costs for selected BAT options.

Within the limitations of the data, all of the above objectives are met. The inventory developed in connection with objective (1) above, focuses primarily on Ontario operations (70% of listed operations), Canada outside of Ontario (12% of listed operations), the United States (90% of listed operations), and Europe (9% of listed operations). The bias towards Ontario operations reflects: (1) emphasis of the defined study scope on Ontario operations, (2) the wealth of data generated for Ontario operations through the MISA monitoring program, compared to that available for other countries and provinces, (3) a diverse geological setting in Ontario which is conducive to the occurrence of a wide range of aggregate deposits, and (4) in many instances a lack of success in obtaining relevant water quality data from operations outside of Ontario.

Preparation of the generic waste water control technologies is comprehensive. However, for various reasons, mostly relating to the limited variety and nature of contaminants released, and cost implications; very few of these generic technologies are actually employed in the industry. Where more unusual waste water control technologies are employed, their application tends to be directed at the specialty clay, and shale and common clay categories.

Therefore, this study is unable to define a large number of applicable BAT technologies. The most common technologies employed are sumps and settling ponds, for control of suspended solids, arranged in various ways. The industry, to a large extent, relies more heavily on Pollution Prevention Practices (PPP) and Best Management Practices (BMP), rather than on a variety of waste water treatment technologies.

All Aggregate Division operations monitored in Ontario currently produce an effluent which is considered non-toxic. Therefore, the likelihood of toxic response within the Aggregate Division appears to be quite small.

Performance of the existing treatment technologies is very difficult to evaluate. The primary reason for this, is that no influent water quality data is available. In addition, many of the effluent treatment systems (principally sumps and/or settling ponds) have not been engineered or otherwise specifically designed to any expected set of performance standards, and much of the effluent released derives from run-off and groundwater inputs. Such flows are highly variable in volume, leading to extremes in system retention times.

10.2 DATA LIMITATIONS

Owing to the limited concern for contaminants associated with most aggregate extraction and process operations, other than for suspended solids; this industrial sector has received limited attention world-wide, as compared to other sectors such as metal mining. Waste water monitoring at many operations is consequently of limited extent, and where present, is generally restricted to suspended solids. Toxicity testing is all but non-existent, other than that associated with the Ontario MISA monitoring program. The preliminary MISA toxicity data available at the time of writing, are discussed within this document.

Since aggregate operations tend to be of local rather than international importance, regulatory controls are most often administered at the municipal or local level. This is in contrast to sectors such as metal mining where national/international concerns have been expressed regarding heavy metal and other contaminants. Exchanges of environmental data and control technologies are consequently quite limited in relation to the Aggregates Division.

10.3 APPROACH TO THE SELECTION OF BAT OPTIONS

Emphasis in the selection of BAT options is placed on: (1) the need to control selected parameters, (2) demonstrated use of waste water treatment technologies within the Aggregates Division, and (3) the feasible application of technologies employed in other industrial sectors.

Evaluation of the need to control selected parameters is based on MISA monitoring data, and on the perceived need of industry members to control such contaminants, as reflected in the world-wide use of control technologies. Following compilation of the Aggregates Division inventory (Table 6-1), it is evident that most waste water treatment systems in use are directed at the control of suspended solids.

10.4 COMPARISON OF REGULATORY STANDARDS

In reviewing regulatory standards world-wide for parameters of interest, most notably pH, suspended solids, and oil and grease, there is general consensus on pH and oil and grease where regulated, but not for suspended solids. Typically, pH is regulated within the range of 5.5 to 9.5. Oil and grease is generally limited at 10-15 mg/L; with the lowest standard at 5 mg/L.

Guidelines and regulations governing concentrations of suspended solids range from a low of 15 mg/L in Ontario to a high of 100 mg/L in Germany. Specific guidelines to the aggregate producers are not available in most countries and only general limits apply, or sites are regulated on a case by case basis within their Certificates of Approval.

Based on the available information from operations similar to those of the Ontario Aggregates Division, Ontario currently has the most stringent guidelines related to suspended solids control.

10.5 BAT OPTIONS

Selected BAT options are defined on a parameter basis. For control of suspended solids, sumps, settling ponds, and sumps in combination with settling ponds are recognized as the Best Available Technologies. Performance of these technologies, where required, can be enhanced through use of flocculants and coagulants although this is not practised by any Ontario Aggregate Division producers.

Separator dykes which facilitate passive filtration are also valued for their effects on suspended solids reduction, and minimizing 'short circuiting' within ponds.

Application of the selected options representing Ontario BAT, US BAT and World BAT is used together with monitoring data to specify estimated concentrations of suspended solids which can be achieved through use of these technologies in the Ontario operations. Actual results will vary depending on-site specifics which can only be addressed through individual site assessment and testwork. A general assumption has been made that sites may reach the levels met by the BAT Plant (where chosen), depending on individual site conditions. The estimated capital and operating costs incurred by application of the technologies are shown in Table 7-1. Estimated costs are based on unit costs of materials supplies and labour and do not include site specific costs related to topography, site availability, unique conditions, etc.

Where deemed to be of concern, oil and grease can be controlled by in-line gravity separators, or through use of surface separators (baffles).

There are no recommended BAT options for treating ammonia or phenolics. These parameters are not specifically controlled by any identified treatment technology other than coincidental treatment for suspended solids and are otherwise best handled through implementation of Pollution Prevention Practices.

10.6 POLLUTION PREVENTION PRACTICES

Pollution Prevention Practices (PPP) are those activities, infrastructure, and/or facilities, which are used in order to minimize the potential for, or impact of, an aggregate operation on surrounding surface waters. The PPP's which apply to the Aggregates Division may be subdivided according to whether the practice is specific to a certain aggregate category, or whether it may be applied universally within the entire Division. Pollution Prevention Practices include Best Management Practices (BMP).

PPP/BMP's differ from BAT's in that they tend to control pollutants at source and provide control of upsets, rather than provide effluent treatment per se. The degree of pollution prevention achieved through use of BMP therefore tends to be more variable and is difficult to quantify. BMP's can also be viewed in some instances, such as operator training, as a means of optimizing BAT performance. Installation of simple measuring and control devices will aid in operator awareness and development of flow history used to formulate flow management strategy.

For these reasons, PPP/BMP's are not regarded as being equivalent to BAT's. However, in certain cases, and particularly for the Aggregates Division where good housekeeping plays such an important role in pollution prevention, the implementation of a PPP/BMP program may successfully fulfil the role of BAT.

The PPP's which are most relevant to the Aggregates Division include:

- recycle of wash water, and
- reuse of effluent for dust control

The BMP's which best apply to the Aggregates Division involve:

- drainage management
- spill management
- storage management, and
- rehabilitation.

Drainage management may involve a reduction in the amount of water inputs, and hence the amount of effluent requiring treatment; and/or, a minimization of the quantity of contaminant entering the effluent stream.

Proper spill management through the immediate clean up of all spills using appropriate techniques, and the placement of spill containment structures around storage areas, may significantly reduce the amount of contaminants entering the effluent stream.

Storage management within the Aggregates Division may inhibit the entrainment of raw materials, and thereby reduce the amount of suspended solids released to surrounding surface waters by run-off.

In addition to storage management, progressive rehabilitation may also significantly reduce sediment inputs to the waste water stream. Grading of slopes and revegetation reduces the amount of material available for entrainment by wind or run-off.

10.7 ZERO DISCHARGE AND VIRTUAL ELIMINATION OF TOXIC CONTAMINANTS

Zero volume discharge is readily attainable throughout much of the south and west of the United States, because the mean annual evaporation exceeds mean annual precipitation. In Ontario, there is a net

precipitation surplus (200-500 mm) in all areas. Zero volume discharge is therefore only possible for those selected operations such as sand and gravel operations, which use a high percentage of recycle. At these operations, groundwater losses frequently preclude surface run-off, and perhaps the operations should not be construed as true zero dischargers.

Progress <u>towards</u> 'zero volume discharge' can nevertheless be made through use of maximum reuse and recycle within the shale and common clay, and quarry categories.

Based upon preliminary toxicity data from the MISA Program, it appears that no aggregate operation that was monitored, currently has an effluent which is considered toxic to either Daphnia magna nor Rainbow Trout (LC50 48 hour and 96 hour test respectively). It is therefore concluded that non-toxic effluents may be generally achievable by producers in the Aggregate Division.

SECTION 11.
REFERENCES

ONTARIO MINISTRY OF THE ENVIRONMENT

INDUSTRIAL MINERALS SECTOR

AGGREGATES DIVISION

BEST AVAILABLE POLLUTION CONTROL TECHNOLOGY

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